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CONSIDERING THE GUIDED MISSILE

"DURING the past 10 years," a distinguished lecturer said recently, "we have gained invaluable experience in the design of [guided] weapons and have now a well-established industry capable of developing and producing a range of advanced weapons. The new teams drew heavily on the knowledge and resources available in the electronics and aeronautical industries and the resultant cross-fertilization has been of value to both. The merging together," he continued, "of system engineering, which has always been a necessary discipline in electronics, with the meticulous design standards of the aeronautical engineer has been particularly fruitful."

The speaker was Dr. R. Cockburn, C.B., O.B.E., Ph.D., controller of guided weapons and electronics at the Ministry of Supply, and the occasion his lecture on "Guided Weapons and Aeronautics" before a meeting of the Royal Aeronautical Society. A brief summary appeared in this magazine last week but we consider that no better text could be taken for an editorial this week than the words quoted at the head of this column. For in this issue we review, so far as is possible, the progress achieved with guided weapons both here and overseas.

One thing becomes apparent from the most cursory survey of our pages and that is the remarkably large number of guided missiles of assorted sizes and performances which have been announced and concerning which information is available. In addition, there must be other developments of which nothing has been released. This is particularly true of Soviet Russia.

However, to return to the main subject of the lecture we are discussing. After consideration of the implication of the nuclear weapon Dr. Cockburn remarks that the strategic bomber has no longer to justify itself by making a large number of sorties; its main purpose is to guarantee the delivery of a single nuclear weapon. Performance over the target as the main criterion has encouraged highly specialized designs, which in turn have forced the close defence fighter to strive for equally extreme performance. Supersonic bombers and fighters, he points out, are so excessively large and expensive and have so little latitude in performance that they are more like projectiles than aircraft.

The fact that the guided weapon is capable of meeting these demands more effectively than manned aircraft is indeed fortunate. At supersonic speeds there is little opportunity for human intervention once a sortie has been committed. Interception by the fighter and precise attack of its target by the bomber have to be done automatically. In fact the crew have become an embarrassment to the designer and an encumbrance during operations. Thus the unmanned expendable missile becomes the primary means of imposing the deterrent and the primary weapon of air defence.

It was the development of lock-follow radar after the War that made the provision of really accurate target information feasible. It allowed error signals to be fed back into the guidance system to give what electronics engineers, and others, called continuous closed loop control. The most developed example of closed loop control is that used in the homing weapon which contains within itself all the sensing and responding apparatus required to intercept a manœuvrable target. It is the homing ground-to-air weapon, according to Dr. Cockburn, which made the replacement of the fighter an achievable objective.

We would comment here that the first two ground-to-air weapons adopted in this country for defence against attacking aircraft are not self-sufficient in this sense. Separate apparatus is needed to sense out the attacking aircraft and the relative position of the missile.

It has already been revealed that the intention in this country is to develop an intercontinental ballistic missile capable of being launched from below ground. Such weapons are practically invulnerable to hostile attack by similar missiles in view of the very high degree of accuracy required for hitting such a tiny target at very long range. On the other hand, there is no difficulty about fixing the position of the launching point geographically with regard to the target, which is absolutely essential for navigational instruction to the long-range missile. This, as is pointed out by a writer in the supplement in this issue, is one of the critical points of the U.S. Navy's remarkable Polaris long-range weapon, which is capable of being launched from a submerged submarine, by virtue of its solid-fuel rocket motor. Clearly such submarine-launched weapons provide a powerful deterrent since they can be launched from positions otherwise inaccessible, from which cities and manufacturing centres can be threatened. But they require a very high degree of accuracy in the navigation of their launching vessels.

Yet however sinister the guided weapon may be, we should not forget that first use of the extremely powerful rocket vehicles, developed for military purposes, has been to launch satellites into orbit as part of man's exploration of space. There can be no doubt that, under the shadow of the uneasy peace maintained by the nuclear deterrent, the peaceful exploration of space will continue.

D

MATTERS OF MOMENT

More Strength for Boulton Paul

AN appointment of very special interest is that, announced last week, of Sir Harold Roxbee Cox, Ph.D., D.I.C., D.Sc., M.I.Mech.E., F.R.Ae.S., to the board of Boulton Paul Aircraft, Ltd.

Sir Harold, now a young 56, was from 1924 until 1929 an engineer involved with the construction of the airship R.101. During that period Boulton Paul Aircraft, Ltd., were also engaged in the design and construction of the hull frame for the airship, and Mr. John Dudley North, now the company's chairman and managing director, was appointed consultant to the Director of Airship Development at the Air Ministry.

Among the many important appointments held by Sir Harold, who was knighted in 1953, have been: deputy director of scientific research, Ministry of Aircraft Production (1940-1943); director of special projects, Ministry of Aircraft Production (1943-1944); chairman and managing director of Power Jets (Research and Development), Ltd. (1944-1946); director of National Gas Turbine Establishment (1946-1948) and chief scientist, Ministry of Fuel and Power (1948-1954). He is now chairman of the Civil Aircraft Committee of the Aeronautical Research Council.

Sir Harold also holds directorships in Wilmot Breeden (Holdings), Ltd., and the Brush Group.

From this list of appointments Sir Harold's long-standing connection with the development of the gas turbine will be apparent. It should not be forgotten that he was an early proponent of the ducted fan. In this connection it will not be overlooked that the latest application of the ducted fan is to VTOL aircraft, in which application the shrouded vanes are used for developing direct lift, as in the Hiller flying jeep.

A Weapon for the V-bombers

AN official photograph has now been released which shows the stand-off bomb that has been developed by A. V. Roe, Ltd., and is to be carried by the Vulcan and Victor strategic bombers. Such bombs will greatly increase the striking ability of the V-bombers, as they can be dispatched when a bomber is many miles from its target and out of the range of defensive surface-to-air missiles. Indeed, they will go some way towards giving the V-bomber an effective supersonic capability.

Interception of the powered bomb itself is a very difficult task, as it is less easy to detect than a bomber and is likely to travel at supersonic speeds similar to those of defensive missiles. Moreover, if the stand-off bomb were to convert some of its kinetic energy into a zoom climb towards the end of its travel, followed by a dive on to the target, defence difficulties would be very great indeed.

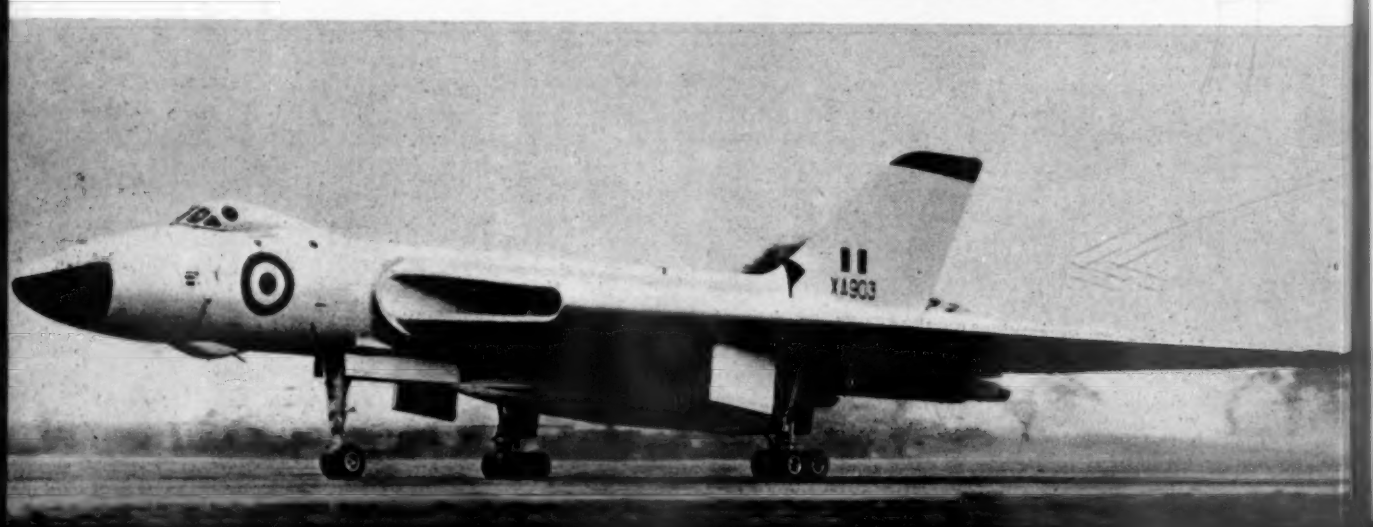
CITY WELCOME.—Marshal of the R.A.F. Sir Dermot Boyle, Chief of the Air Staff, and Lady Boyle are received by the Master and Wardens of the Worshipful Company of Coachmakers and Coach Harness Makers at their annual Livery Dinner in the Mansion House on April 14. Here Sir Dermot is being greeted by the Master, Mr. R. J. D. Smith, and Lady Boyle by Sir Reginald Verdon Smith. An account of the dinner is on page 600.

No details of the performance of these weapons have been given. Nor has it been explained in detail how they will be operated. But presumably a stand-off bomb could be programmed to fly a roundabout course to its target. For example, a weapon travelling at 1,500 m.p.h. and with a range of 500 miles could hit a target anywhere inside an area of 750,000 sq. miles—more than one-third the area of Europe—within 20 minutes after it was released.

It has been stated that the British stand-off bomb will initially be rocket-powered; the engine which has been mentioned is the de Havilland Spectre, which produces some 8,000 lb. of thrust. The range of a rocket-powered weapon, however, is likely to be restricted because of its high consumption of fuel and oxidant.

In the recent debate on the Air Estimates it was stated that powered bombs of considerable range were being developed. It is logical to expect that weapons with a longer range than that of the initial version will be developed and powered either by supersonic turbojet engines, such as the Gyron Junior, or by ramjets. As release is from a fast-flying V-bomber no rocket boost would be needed to accelerate ramjet engines up to a speed where they produced the necessary thrust.

The officially released photograph of the stand-off bomb is not very revealing. It shows, however, that the weapon is



This first photograph of Britain's stand-off bomb—which has been developed by the Avro company under an M.O.S. contract—shows how it is carried under the fuselage of the Vulcan.

carried externally beneath the Vulcan and is apparently of the order of 35 ft. long and about 5 ft. in diameter. It appears to have a small slim-delta foreplane and low-aspect-ratio delta wing, indicative of a supersonic cruising speed. A small protuberance can be seen at the rear of the bomb-aimer's window bulge beneath the Vulcan cockpit. This is probably a periscope or camera for viewing the release of the stand-off bomb.

The Russians at Brussels

AMONG the Russian exhibits at the Brussels Exhibition, which opened on April 17, is an aeronautical section containing models of some of the new Soviet civil air transports, with photographs and official figures of their leading characteristics. Russian aviation technicians are also in attendance at the exhibition, and are apparently willing to discuss details of the new aircraft.

Figures for the Ilyushin Il-18 Moscow agree fairly closely with those published in our issue of November 8, 1957, which were also from Russian sources. An interesting additional item of information, however, is that the Moscow may be powered either by four Kuznetsov NK-4 or Ivchenko AI-20 turboprop units, each of 4,000 h.p. The span is 122.6 ft.; the length, 117 ft.; height, 33.4 ft.; gross wing area, 1,507 sq. ft., and mean t/c ratio, 14%. When fitted out to take 100 passengers, the Il-18 has an empty weight of 61,730 lb.; the max. payload is 30,860 lb.; and the gross weight, 119,000 lb., with 3,210 gal. of fuel. With 75 passengers and 5,280 gal. of fuel, the payload is 26,450 lb., and the maximum gross weight, resulting in a wing loading of 85 lb./sq. ft., is 127,860 lb.

Cruising speed of the Il-18 is given as 403 m.p.h. at 26,250 ft., and the range, with 1-hr. reserve fuel, as 1,860 miles. Typical take-off and landing distances are 2,700 and 1,750 ft.

Official particulars for the Antonov Ukraine transport are given for the first time, and mention is also made of the new designation An-10A. The span of this aircraft is 124.6 ft.; length, 121.3 ft.; height, 32.1 ft.; and wing area, 1,293 sq. ft. With a maximum payload of 31,600 lb. and a fuel load of 2,820 gal., the max. gross weight is 121,500 lb., and the wing loading 88 lb./sq. ft., while the range at 32,000 ft. with 1 hr. reserve is 1,240 miles.

Maximum speed of the An-10A at 26,250 ft. is quoted as 483 m.p.h., while the range with a 23,000-lb. payload is 1,927 miles, increasing to 2,127 miles as the payload comes down to 18,600 lb. Maximum take-off run is 2,300 ft., and the landing run is similar, except when airscrew braking is used, when it becomes about 1,600 ft. Initial climb is 1,960 ft./min., decreasing to 1,278 ft./min. on three engines, and 472 ft./min. on two.

News of a Thriving R.Ae.S. Branch

A RECORD year for the Brough Branch of the Royal Aeronautical Society has been claimed by the chairman in his annual report. Total membership is now 428—compared with 359 last year. Of this total, no fewer than 128 members are also members of the main Society and 83 new members have been enrolled. By comparison with other R.Ae.S. branches, the Brough Branch total of 128 main Society members is sixth in the country and "with one more we should be equal fifth."

During the winter, the Branch held eight lectures at which the average attendance was 101. Altogether at lectures and film shows the total attendance has been 1,680, which, as the chairman said, is a figure that should give much satisfaction to the Committee for the hard work they have put in during the year to make Brough one of the Society's more thriving branches. He paid a tribute, incidentally, to the Blackburn and General Aircraft Company for their support—financial and otherwise—without which, he said, the Branch would really be struggling.

For 1958/59, Mr. N. E. Rowe, C.B.E., D.I.C., B.Sc., M.I.Mech.E., F.R.Ae.S., F.I.Ae.S., the company's technical director, will again be president of the Brough Branch. And Mr. B. P. Laight, M.Sc., A.M.I.Mech.E., F.R.Ae.S., their chief designer, succeeds Mr. M. G. K. Byrne as chairman.

Aeronautical Exhibits at Olympia

THIS year's Instruments, Electronics and Automation Exhibition at Olympia, which closes today, covered one-third more floor area than in 1957, and for the first time included overseas manufacturers from Europe and the United States. Of the 250 home exhibitors, suppliers to the aircraft industry were well represented in the fields of aeronautical radar, communication, navigational and instrumentation equipment, as well as in the industrial applications of their developments.

One of the most interesting exhibits in the field of automatic

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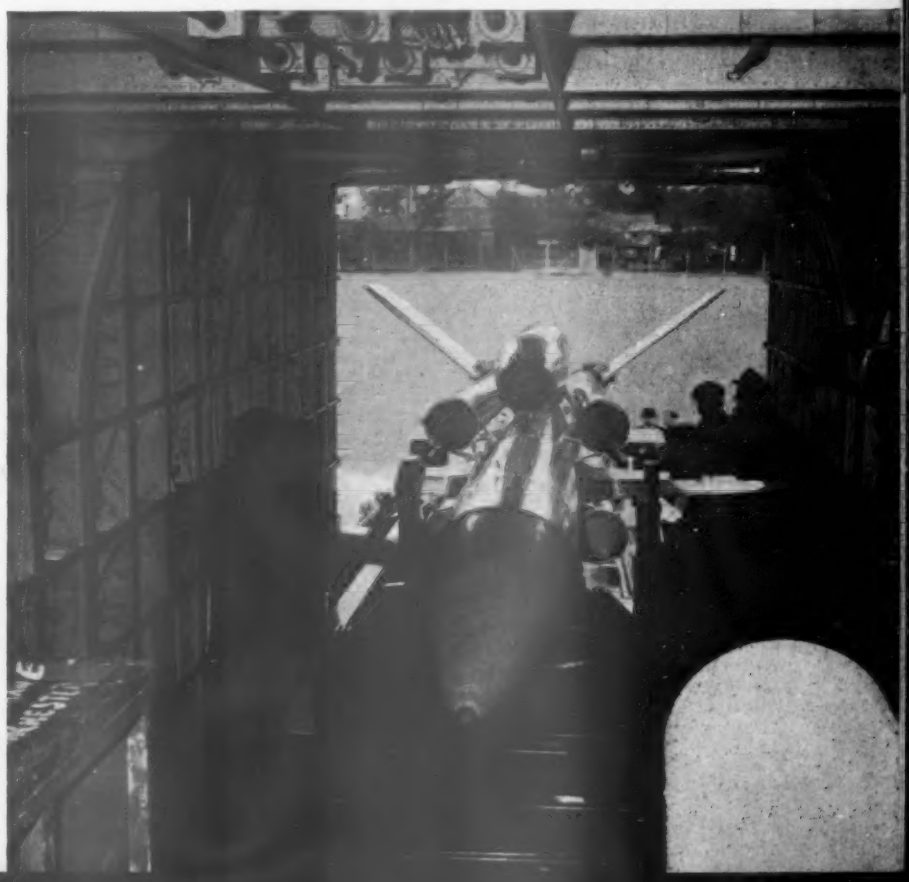


MOBILE MISSILE.—With room to spare, a Bristol Bloodhound surface-to-air missile, complete with its transporter trolley and ancillary equipment, can be loaded into the capacious hold of a Transport Command Beverley when rapid transport of these weapons from one place to another is required. Another view is on page 576.

machine tools was the Fairey-Ferranti, three-dimensional, electronic programme-controlled, high-speed contour milling machine for producing integrally formed large aircraft structural components. Displayed with photographs and other details on the Ministry of Supply Air Division stand, this machine takes advantage of the latest automation and electronic methods to produce airframe components at a fraction of the normal cost and machining time.

Costing approximately £85,000, it has a 28 ft. by 8 ft. work table, a machining capacity of 25 ft. by 7 ft. by 1 ft., and a maximum peripheral cutting speed of 12,000 ft./min. Designed to machine components principally from rolled and stretched light-alloy stock, it has a digital control system developed by Ferranti, Ltd.

Planned to replace the present standard VHF transmitter/receiver in military aircraft when the Services transfer to UHF communications, the AN/ARC-52 UHF airborne equipment manufactured by the Plessey company, under licence from the Collins Radio Co., was on show. Operating in the 225 to 399.9 Mc/s range it has 1,750 frequency channels available through manual control plus 15 preset channels, and a second fixed tuned transmitter/receiver for operation on an international distress frequency. At 50,000 ft. the air-to-ground range of the AN/ARC-52 should exceed 200 miles.

A number of companies displayed missile guidance and other components, and instruments used in guided-weapon development work. S. G. Brown, Ltd., showed their Master Reference Gyroscope system for aircraft, airborne radar stabilizing equipment and missile actuators; Black Automatic Controls, Ltd., displayed solenoid valves and pressure switches for missile systems. An analogue computer used for missile work was on the Elliott Bros. (London), Ltd., stand, and Kelvin and Hughes (Industrial), Ltd., exhibited high-frequency recording equipment used in missile development.

An Aerodrome for Sale

ALTHOUGH Thruxton aerodrome, near Andover, Hants, is to be put up for sale by auction at the end of June, the Wiltshire School of Flying, which has been in possession for the past 12 years, will continue to occupy it under the terms of the lease now in force. This lease is for an indefinite period and the terms cannot be increased. The Ministry of Town and Country Planning has approved the land for use permanently as an aerodrome. The Wiltshire School of Flying will make a bid for the land.

The Thruxton Manor Estate was purchased by the Air Ministry in 1940 and the aerodrome became operational in May, 1941, for use by R.A.F. Army Co-operation Command. It was associated with glider-towing and airborne troop operations until the end of the War, being occupied by the U.S.A.F. early in 1944. It became inactive from a military viewpoint in 1946; the Wiltshire School of Flying took over the property soon after and has operated there ever since.

The aerodrome has a concrete runway, with the customary perimeter tracks, hard standings and dispersal points, control tower, hangars and workshops. In addition to the aerodrome there are about 100 acres of agricultural land.

Conference on Space

AN eager and attentive audience—over 2,000-strong—was at the Royal Festival Hall on April 14 when H.R.H. The Duke of Edinburgh opened a youth conference, "Britain Enters the Space Age," sponsored by the Air League of the British Empire. In his address His Royal Highness emphasized that the fact that Britain had no immediate plans for space travel was not because of lack of willingness of scientific brainpower but because of the tremendous cost of the kind of research required. The chairman of the Conference was Marshal of the R.A.F. Sir Dermot Boyle, G.C.B., K.C.V.O., K.B.E., A.F.C., Chief of the Air Staff.

The first of the four speakers who provided the basis for the subsequent discussions was Professor W. H. McCrea, F.R.S., Ph.D., B.Sc., F.R.S.E., M.R.I.A., secretary of the Royal Astronomical Society. He talked about the place of space travel in current scientific and technological developments, and discussed its general principles. He was followed by the senior technical manager (guided flight) of Elliott Bros. (London), Ltd., Mr. J. E. Pateman, A.M.I.E.E., who referred to some of the problems encountered in the navigation and guidance of rockets and satellites.

Next came Mr. D. G. King-Hele, M.A., of the R.A.E., who proved a fount of information with the data which he gave on the lives of the four satellites which have been put into orbit. He also described the methods of observation employed by the R.A.E.

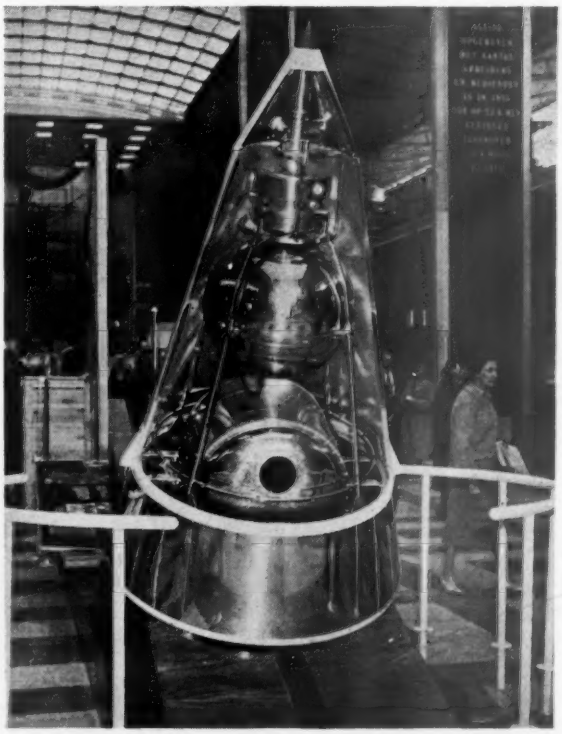
The last of the four speakers, Mr. Arthur C. Clarke, B.Sc., F.R.A.S., spoke very much in the future tense—forecasting that in 20 years' time man would have landed on the Moon and by the end of the century would be on Mars and Venus. On the subject of cost, Mr. Clarke was very forthright. "If anyone thinks that space research is beyond the resources of this country," he said, "I should like to point out that the money thrown away in developing aircraft types which were scrapped even before they flew could have put a British satellite into space before Sputnik I."

The last part of the conference took the form of a Brains Trust in which the four speakers, with the addition of Professor H. S. W. Massey, F.R.S., B.A., M.Sc., Ph.D., LL.D., formed a panel under the chairmanship of Sir Arnold Hall, F.R.S., M.A., A.C.G.I., F.R.Ae.S., to answer questions put to them by members of the audience. This was a very lively session for the questions were put by people of all ages—and ranged from "Have space ships got portholes?" to "What is the panel's opinion that at a speed close to that of light, time ceases to exist?"—R.S.H.

The B.O.A.C. Cuts

FOLLOWING a B.O.A.C. management decision that, in the interests of efficiency, there would need to be cuts in engineering staff numbers, a meeting of the staff last Monday called for an immediate ban on overtime and the application of "work to rule" tactics "as and when required."

According to a trade union speaker at the meeting, B.O.A.C. intends to displace 3,150 men during the next two years—650 of them during the coming six months and the remainder during the following 18 months. A B.O.A.C. spokesman said that the ban would not be likely to have any immediate effect on the Corporation's services.



SATELLITE SEEN.—A centre of interest in the Russian section of Brussels' International Exhibition is this replica of Sputnik II which completed 2,370 orbits before re-entering the Earth's atmosphere on April 14 and disintegrating.

News of Aircraft, Engines and Missiles

MODIFIED MiG.—This first detailed ground photograph of the MiG-19 Soviet interceptor also shows the significant addition of a shock cone inside the nose intake for the twin turbojets. Early MiGs did not have this feature, which may also house radar, but the ventral strake is common to all variants.

HANOVER FAIR. — An exhibition of aircraft tools, equipment and accessories, arranged by the Federation of the German Aircraft Industry, is to take place, as part of the German Industry Fair, at Hanover Airport from April 27 to May 6. Fifty companies will show their products, including several examples of post-War sporting and transport aircraft and gliders, and there will also be foreign participation.

MIXED POWER.—Mounted in the tail of the Aerfer Ariete is a 1,860-lb. thrust Rolls-Royce Soar R.Sr.2 short-life turbojet. A retractable air intake is located behind the cockpit. The main powerplant is a Rolls-Royce Derwent 9 turbojet in the belly of the aeroplane.

THE ANNUAL REFERENCE

THE 1958 edition of "THE AEROPLANE Directory of British Aviation" is published today. It costs 30s. from all booksellers and bookstalls, or 31s. 9d. direct from the publishers, Temple Press Limited, Bowling Green Lane, London, E.C.1.

GLIDING IN BRITAIN.—The B.G.A. has announced that a National Gliding Week will be held from July 27 to August 9. Meetings will be held simultaneously at the Derbyshire and Lancashire G.C., Camphill (Centre Region); London G.C., Dunstable (London Region); Yorkshire G.C., Sutton Bank (Northern Region); Scottish G.U., Portmoak (Scottish Region); Kent G.C., Detling (South-eastern Region), and the Bristol G.C., Nympsfield (Western Region). Contests for free distance, straight-line distance, pilot-selected goal and speed flight will be set each day. The closing date for entries is June 19. Those interested should contact Mrs. A. Ince, 3 Queens Gardens, London, W.5.

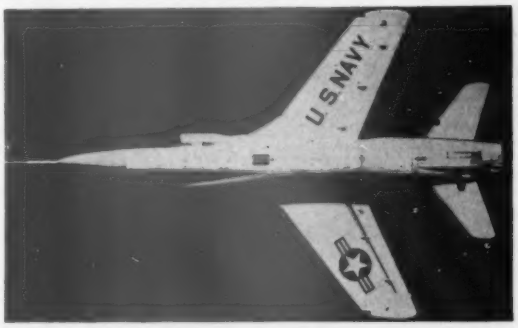
ANTONOV'S BEE.—Features of the new Antonov An-14 visible in this first ground photograph include the rear loading doors and extensively slotted ailerons and flaps.

JET-FLAP RESEARCH. — Hunting Aircraft, Ltd., is designing a jet-flap research aircraft. Full details are not available, but it is probable that the aircraft is based on the Jet Provost trainer and is being built under M.o.S. contract.

NEW CESSNA.—Described as a replacement for the Cessna 140 is the Model 150, the prototype of which has been flight tested and is due to enter production next autumn. This will be the seventh Cessna type in production, and an eighth may be added next year. In the last week of March the Cessna company delivered 215 aircraft, valued at $3,250,000.

TURBINE ORDER.—Lycoming has received a joint order from the U.S.A.F. and the U.S. Army worth about $10 million, for the delivery of T53-L-1 helicopter gas-turbine engines. They are to power the Bell HU-1 Iroquois and the Kaman H-43B. A new turboprop version of the T53 is to power the Grumman AO-1 Mohawk.

AMERICAN AID.—Lockheed Aircraft Service-Overseas, Inc., is to provide technical assistance and material, under a $22 million contract, to the Kawasaki Aircraft Co., of Japan, which is to build the P2V-7 Neptune for the Air Self Defence Force.



STILL HIGHER.—A new aeroplane height record is being claimed for a Grumman F11F-1F Super Tiger, which has reached 76,828 ft. The present record of 70,310 ft. was set up by the Scorpion - Canberra in August, 1957.

RUSSIAN TRAINER.—The Yak 18P is a new version of the Yak-18A, and is designed primarily as an advanced aerobatic trainer for the clubs of DOSAAF. It is a single-seater with full retractable nosewheel undercarriage, modified forward fuselage, and a 260-h.p. Ai-14P engine. Dimensions are as for Yak-18A. Weight empty, 2,000 lb.; loaded weight, 2,315 lb.; max. speed at sea level, 186 m.p.h.; rate of climb, 1,575-1,772 ft./min.; range with extra fuel (max.), 932 miles; take-off run, 104 yd.; landing run, with full flap, 186 yd. The prototype is being tested. An inverted-flying fuel system will be provided in production aircraft.

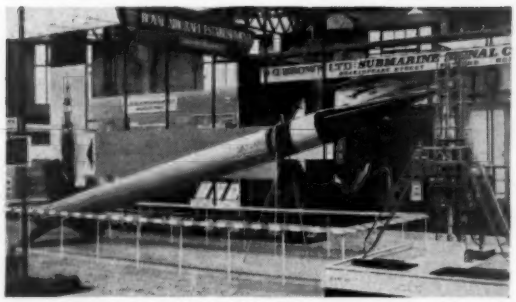
FRENCH SAILPLANE.—The Breguet 905 Fauvette single-seat sailplane made its first flight at Aire-sur-l'Adour on April 15, piloted by M. Paul Lepanse. It is to fly in the forthcoming World Championships in Poland.

DOUBLE DELTA.—The first flight of the Convair F-106B, two-seat version of the F-106A Delta Dart, was made at Edwards A.F.B. recently.

NEW VERTOL.—Ground tests of the Vertol 107 tandem-rotor commercial helicopter are being made at Philadelphia international airport. The Model 107 is powered by Lycoming T53 free-shaft turbines and will carry about 20 people.

DOUBLE CENTURY. — Dr. John Hagen, director of the U.S. Navy's Vanguard programme, has said that the Vanguard satellite, launched in March, is expected to circle the Earth for 200 years.

MAN IN SPACE.—Dr. Werner von Braun said in Washington on April 15 that the U.S. Army wants to send a man 100 miles into space in the nose of a Redstone missile and bring him back safely to Earth. Volunteers have come forward.



HIGH ENDEAVOUR.—A Skylark research rocket was recently fired from Woomera to a height of 90 miles. Pictured here is an example which was shown at the Instruments, Electronics and Automation Exhibition at Olympia, London.

Photograph copyright "The Aeroplane"

BRITAIN IN HANOVER. — D. Napier and Son, Ltd., will exhibit the Eland, Gazelle and Double Scorpion aero-engines, missile rocket-motors and "Napiercast" castings at the forthcoming Hanover Trade Fair.

REPUBLIC NEWS. — Sales of $269,017,856 (about £96,200,000) for 1957 are announced by the Republic Aviation Corpn. Profits after the deduction of taxes amounted to $6,102,631 (£2,180,000 approx.). Eleven F-105 Thunderchiefs have now been delivered to the U.S.A.F. and are under test.

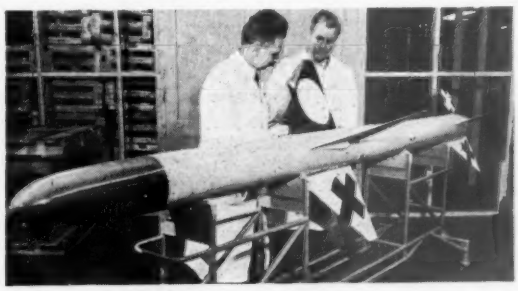
U.S. RAM-JETS.—Designations of several Marquardt ramjets have been given in the company's annual report. They include the RJ43-MA-1, tested in the Lockheed X-7A-1 test vehicle; the RJ43-MA-3 for the Boeing XIM-99A Bomarc; the RJ43-MA-5 developed for the Lockheed Q-5 drone; the RJ43-MA-7 tested in the X-7A-3 and used in the XIM-99B. The RJ57 is also mentioned and the RJ59 has been tested in the X-7A-2. Marquardt ramjets have flown at Mach=3.95 and above 100,000 ft. in the X-7s.

RYAN REVENUE.—Net earnings of the Ryan Aeronautical Co. for the first quarter of the 1958 fiscal year totalled $510,146 (about £182,000). This is an increase of 72% over the amount earned in the same period last year.

TANKER GENERATORS. — The Solar Aircraft Co., of San Diego, Calif., has been awarded a $3,000,000 contract by the U.S.A.F. to build gas-turbine powered airborne generator sets for the Boeing KC-135 jet tanker. The generators are powered by Solar Mars gas-turbines.

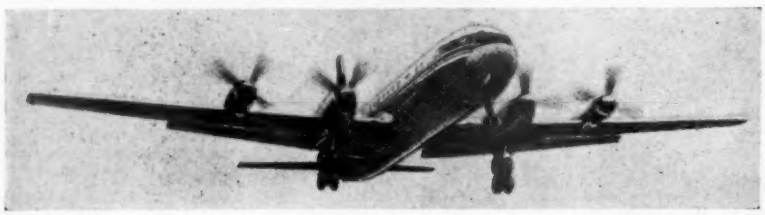
FLIGHT MEMORIAL.—The building erected at Adelaide Airport to commemorate the flight of Sir Ross and Sir Keith Smith from England to Australia in 1919 will be opened on April 27. It contains the Vickers Vimy in which the flight was made and statues of the brothers and of the members of their crew.

FIGHTER COMMAND.—Replying to questions put by Sir Arthur Vere Harvey and by Mr. Lucas, the Air Minister, the Hon. George Ward, said in the House recently that "no change is contemplated in the status of Fighter Command . . . there is a continuing need for Fighter Command in the circumstances described in the White Paper."



PROTOTYPE. — Canada's first operational guided missile, the Sparrow II, is now being built by Canadair, Ltd., Montreal, as co-ordinating contractor.

Commercial Aviation Affairs



ILYUSHIN APPROACH.—An Il-18P Moscow comes in to land, with its large-area slotted flaps and trailing bogey undercarriage extended. The Il-18 can have either Kuznetsov NK-4 or Ivchenko AI-20 turboprop engines.

VISCOUNT TO BERMUDA.—Eagle Airways Viscount 805 G-APDW left Blackbushe last week-end for Bermuda. It has been re-registered VR-BAX and will be used on the Eagle Airways (Bermuda) service from Bermuda to New York. The second Eagle Viscount, G-APDX, is in service on the parent company's scheduled services from the U.K.

SUPER-WAYFARERS. — Bristol 170 Mk. 32s fitted to carry 60 passengers are to be used by Silver City Airways on their Ferryfield-Le Touquet air link in the Silver Arrow coach-air-rail service from London to Paris which starts on May 21. Known as Super-Wayfarers, they will be the first all-passenger versions of the Mk. 32 Freighter.

FIJI PURCHASE.—Qantas Empire Airways have bought Fiji Airways and appointed Capt. R. O. Mant as manager. Capt. Mant was previously assistant operations manager with Qantas. Fiji Airways, formed in 1951, was previously operated by Katafanga Estates and the original managing director was the late Mr. Harold Gatty. With three Drovers and a Rapide, Fiji operates over a 550-mile network from Suva—including a service connecting Suva with Nandi, the international airport.

F-27 NEWS.—Pacific Air Lines (previously Southwest Airways) has increased its order for Fairchild F-27s from three to five. All P.A.L. Friendships will have Dart R.Da.7 engines. The first F-27 built by Fairchild began its flight trials on April 17.

ATLANTIC INCREASE. — Pan American advance bookings on the North Atlantic for June are 20% above the figures for last year, and reflect strong interest in economy fares. In January and February, all air carriers on the Atlantic carried 14% more passengers, eastbound, than in the first two months of 1957.

SABENA WIDGEON.—For the duration of the Brussels Exhibition Sabena is using this Westland Widgeon for sight-seeing tours and special charter flights. Seen at Yeovil are, left to right, Lt. W. H. Sear; M. A. Vernieuwe Sabena's senior vice-president; Mr. E. C. Wheeldon; M. Georges Perrier, Sabena president; M. Pirson, the technical director; and Cmdt. G. Tremerie, Sabena's chief helicopter pilot.

AND NOW TORONTO.—Plans have been announced for the development of a new passenger terminal at Toronto Airport, Malton, on which work will begin this year. Like the new terminals at Montreal and Winnipeg, recently announced, it will have a central structure housing administrative and operational offices, and four " aeroquays " linked to it by underground tunnels. Each aeroquay will have a multi-storey parking structure for travellers' cars, and a flat roof for use by helicopters.

AERONAVES PRAISE.—Aeronaves de Mexico, operating Britannias on six scheduled services a week between Mexico City and New York, have now totalled 4,260 engine hours on their Proteus turboprops. During this period, the company states that it has not suffered a single delay in schedule because of engine trouble.

DOPPLER TRIALS. — Following intensive paper evaluation, the Canadian Marconi Co.'s airborne Doppler navigation system has been selected by six airlines for operational evaluation.

BRITANNIA EXTENSIONS.—B.O.A.C. introduced Britannia 312s on the London-Montreal-Detroit-Chicago route on April 17, at an initial frequency of twice a week. There will be a daily service by June, with economy, tourist and first-class or de luxe seats on all flights. The Britannia 102 service to Teheran was to open on April 22, and on May 3 a stop at Melbourne will be added to two services each week on the London-Sydney route by Britannia 102s.

EAST AFRICAN PROFIT.—A net profit of £5,185 was returned by East African Airways for the calendar and financial year 1957. Before paying interest on stock and providing for other charges the profit was £14,518. The most notable traffic figure for the year was that for revenue passenger-miles, which was 38,856,134—an increase of about 10 million on the 1956 figure. This increase follows the introduction by East African of the long-haul services with DC-4Ms.

LOT LOSS.—One of the three ex-Sabena Convair 240s operated by LOT crashed on April 11 on a training flight in Poland, injuring the four crew members. The accident is reported in Poland to have followed the loss of one propeller.

SPANISH LOSS.—Sixteen people were killed when a de Havilland Heron operated by Aviaco crashed into the sea a few miles from Barcelona on April 14. The accident is reported to have resulted from violent manœuvres made to avoid an aircraft of Iberia Airlines.

Military Aviation Affairs

CADET INTERCHANGE. — Once again this year air cadets of 16 nations will make reciprocal visits under the auspices of the International Cadet Exchange Scheme. Countries participating are Belgium, Canada, Denmark, France, Greece, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, Great Britain and the U.S.A. Visits will be from one to three weeks' duration. The Air Council was due to give a dinner tonight, April 25, in honour of the delegates attending the planning conference.

R.A.F. CONCERT. — An R.A.F. Anniversary Concert, to commemorate the 40th Anniversary of the foundation of the Service, was held at the Royal Festival Hall on April 18. The concert, by the Hallé Orchestra and the Central Band of the R.A.F., was given in the presence of H.R.H. the Duchess of Kent, President of the R.A.F. Benevolent Fund, to which all the proceeds are to be donated.

ARGENTINE VISIT.—Two Avro Vulcans of No. 83 Sqn. are to visit Argentina to give flying displays when the Hon. George Ward, Secretary of State for Air, attends the ceremonies to mark the installation of Dr. Arturo Frondizi as President of the Argentine Republic on May 1. He will travel in a Transport Command Comet.

W.R.A.A.F. COMMANDANT.—H.M. The Queen has approved the appointment of H.M. Queen Elizabeth The Queen Mother as Air Chief Commandant of the Women's Royal Australian Air Force.

R.A.F. BUTTERWORTH.—Gp. Capt. K. R. J. Parsons, D.S.O., D.F.C., A.F.C., R.A.A.F., has been appointed to command R.A.A.F. Butterworth, Malaya, with effect from June 1, with the acting rank of Air Cdre. R.A.A.F. operational squadrons are to move from Australia to Butterworth later this year.

ROUND THE WORLD.—The R.A.F. Flying College Canberra " Aries V " was to start on a 28,340-mile round-the-world flight on April 21 and is due to return to the U.K. on May 14. The exercise, named " Eastabout," has two objects—to practise and develop navigational techniques for areas with limited ground aids, and to discuss operational and training matters with Commonwealth air forces. During the same period, " Aries IV," also a Canberra, is flying to N.Z. and back.

News About People

ELECTRONIC POSTS.—Mr. Gordon A. Spencer, A.R.T.C., M.I.E.E., has resigned his appointment as principal scientific officer with the Admiralty Signal and Radar Establishment to join Andec, Ltd., electronic engineers of Reading. Mr. H. F. C. Williams, B.Sc., formerly of Racall, Ltd., is now chief electronics engineer of Andec.

DUNLOP AWARD. — Mr. G. E. Beharrell, Dunlop chairman, has received the R.A.C.'s Dewar Award for his company's work on disc brakes and tyres.

ROYAL ENCOURAGEMENT.—H.R.H. The Duke of Edinburgh, seen here being greeted by Sir Arnold Hall, attended a youth conference on space travel on April 14. Next to Sir Arnold is Marshal of the R.A.F. Sir Dermot Boyle who was chairman of the conference. A report of the occasion is on page 560.

JACKAROO DESIGNER.—Jackaroo Aircraft, Ltd., of Thruxton aerodrome, Andover, Hants, informs us that for the past year Mr. Eric H. Smith, D.C.Ae., A.F.R.Ae.S., has been chief designer.

ROTOL RESIGNATION.—Mr. L. S. Armandias has, by mutual agreement, terminated his association with Rotol, Ltd., and British Messier, Ltd., as from March 24 last.

LUFTHANSA APPOINTMENT. — Mr. Walter Lehmann has been appointed station manager for Lufthansa at London Airport. He was previously assistant station manager, and succeeds Mr. Herbert Summ, who has returned to Germany.

AIR STRATEGIST.—Air Cdre. Lionel Evelyn Oswald Charlton, C.B., C.M.G., D.S.O., who died on April 18, aged 78, was one of this country's greatest exponents of air power, and was a prolific writer on the subject. Transferring from the Army to the R.F.C. in 1914 (having served in the Boer War) he soon gained a reputation as a staff officer of some standing. He was closely involved with aspects of strategy, and from 1919 to 1922 was Air Attaché in Washington. He saw service in Iraq (1923-24) as C.S.O. On leaving the Service he devoted his time to producing many books which emphasized his views on air power.

AIR TRANSPORT

Two New Operators

AN official announcement in Accra on April 14 gave the news that the Ghana Government has decided to set up a national air transport operating company, Air Ghana, with the help of B.O.A.C. Proposals had been made by several major international operators and, of these, that by B.O.A.C. had been accepted as the most suitable. The Corporation has been invited to send representatives to Accra to complete the contract.

To begin with, it is likely that B.O.A.C. will second managerial, operational and administrative staff to Air Ghana, while nationals are trained to take over as much responsibility as possible. The Government announcement speaks of the intention to operate domestic and international services " to the highest standards."

The Government of Nepal is also taking steps to establish a national airline, in which it will hold a 51% interest. A seven-man committee, headed by Prince Himalaya, has been set up to arrange for the new company to be formed. A licence for domestic flights in Nepal is held at present by Indian Airlines Corporation Associates (the B. Patnaik company) and Indian Airlines itself operates a service between Katmandu and Patna.

Our Bombay correspondent reports that Patnaik has offered to form an Air Nepal company and to provide all necessary personnel to continue the existing domestic services, which are operated with four DC-3s.

Jet Operating Techniques

SOME details of the way in which Pan American will overcome various of the problems associated with turbojet operations were given at a recent conference held by the airline. Pan American expect to be the first U.S. airline to use turbojet transports, with Boeing 707-120s in use before the end of this year on the North Atlantic route, and 707-320s and DC-8s on order.

Among the interesting points made in the course of the symposium was the fact that Pan American propose to use uninterrupted interior layouts, featuring the long, straight, tube effect, with four galleys (two at each end) able to serve 192 tourist-class meals in 36 minutes. Because of short flight times, no berths will be provided on the 707-120. Pressurization will be by air-driven compressors which have replaced the engine-bleed system used on the prototype.

The 707-120 will use water injection for the take-off and climb to 400 ft., requiring 5,200 lb. of water per engine at a rate of 40,000 lb. an hour. The take-off run of the 707-120 at its present gross weight of 246,000 lb. is given as 9,800 ft. at sea level in I.S.A. + 15° C. (86° F.) with no wind or runway slope. The JT-3C engines will have combined suppressor-reversers of the internal cascade type developed by Boeing. These are estimated by Pan American to cost up to $30,000 each in first cost and more than $86,000 a year to use, per aeroplane, exclusive of maintenance. They will cut take-off thrust by 1-2½%, and reduce the cruising mileage per pound of fuel by 2-4%.

A plan has been devised for instrument approaches at Idlewild in which incoming jet aircraft would be held at 20,000 ft. in an area away from the piston engine stack, and would descend to 2,500 ft. in controlled steps before entering the approach pattern. Crews for the 707 will be selected according to seniority and regardless of age, and will comprise, on trans-atlantic operations, captain, first officer, flight engineer and navigator, with no reserve crew.

On the bigger Boeing 707-321 and the DC-8, Pan American plan to carry spare engines externally on regular scheduled flights if emergencies arise along the routes. They would be carried, as complete pods, inboard of the port inner engine.

Coach-Air to Brussels

SKYWAYS introduced a useful Coach-Air service to Brussels on April 17, the opening day of the Brussels International Exhibition. The service operates twice a day each way between Lympne and Antwerp, with a coach connection to the Exhibition grounds. Fare is £12 18s. 0d. plus the coach fare in Belgium.

The service, with departures from Lympne at 08.15 and 15.30 hrs., and from Antwerp at 10.45 and 17.45 hrs., will make a day visit to the exhibition practicable, and to this end, Skyways are offering a package trip at 14 guineas per person, which includes overnight accommodation and dinner at the Grand Hotel, Folkestone, and all necessary coach transport up to the arrival back at Lympne next day.

THE EIGHTH COMMERCIAL.—Fine lines of the Douglas DC-8 are well shown in this picture, taken as the first aircraft was rolled out of the assembly hall on April 9. The Douglas-sponsored production of the DC-8 is one of the most expensive programmes ever undertaken by private industry.

Air Transport Developments in Japan

by Henry M. Kingsley

The control tower at Tokyo International Airport.

IN less than seven years Japan has leaped from complete inactivity in air transportation to a position in the forefront of the industry in Asia and the Pacific with an excellent reputation for technical and commercial efficiency. In this short space of time Japanese scheduled air services have developed from a few internal links to a comprehensive domestic network and international routes to south-east Asia, the United States and South America. During the same period its commercial air fleet has grown from four chartered Martin 202s to an impressive array of Douglas equipment including four DC-7Cs, five DC-6Bs and 10 DC-4s (owned by Japan Air Lines who will be one of the first airlines to fly DC-8s over the Pacific) plus a large variety and number of smaller types—DC-3s, Herons, Doves, Beavers, Marathons, Autocars and Cessnas—which are used by the domestic feeder line, All Nippon Airways, and the several flourishing non-scheduled and charter operators.

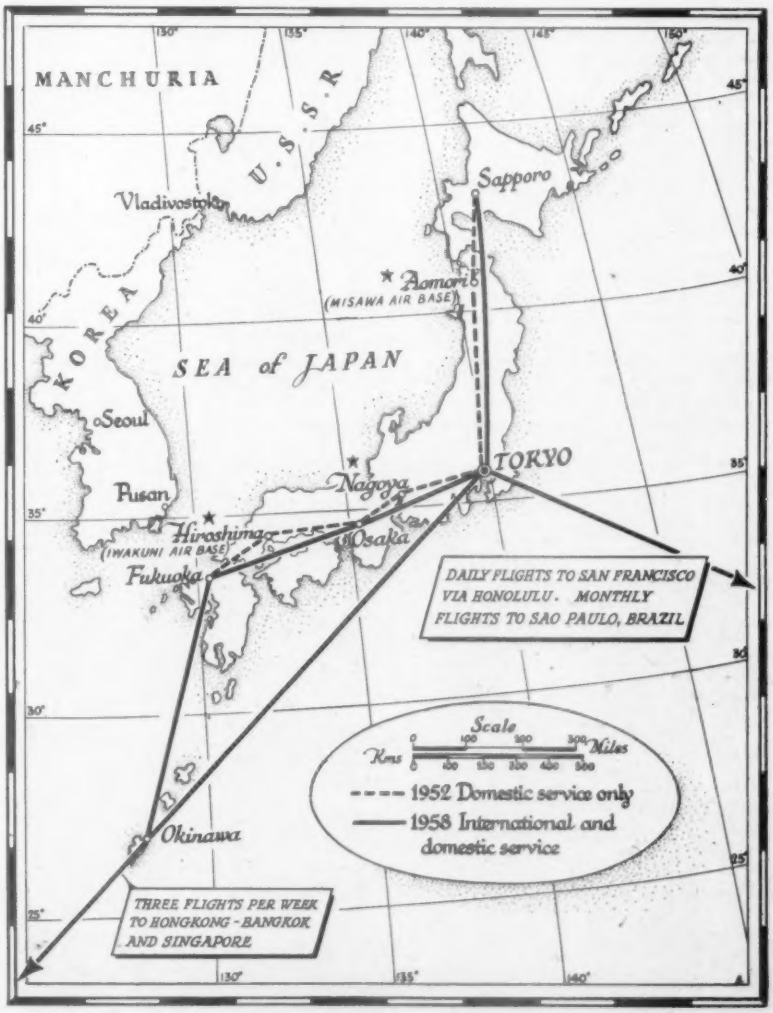
In the past three years alone, air passenger traffic carried by Japanese companies has more than doubled. Japan Air Lines, the national flag-carrier, has just announced a net profit for 1957 of $2,790,322, a handsome figure with which many an airline three or four times larger would be well satisfied. Since 1953 the Japanese have given their full support to air transportation's international agencies. The government and Japan Air Lines, respectively, are members of I.C.A.O. and I.A.T.A. and, in both of these bodies, their interest and activity represents far more than a mere prestige participation. For a country whose people, less than a decade ago, were still forbidden to take part in any kind of aviation activity, this is an admirable record.

Japan is far from being a newcomer to civil aviation, however. It started air mail operations in 1919—Tokyo-Osaka; domestic services began in 1922—with Japan Air Transport's Osaka-Takamatsu-Tokushima service; and international services—Osaka-Shanghai by the same company—followed in 1926. By 1940 several routes had been established to south-east Asia and the Pacific.

Since the end of the Second World War, air transportation in Japan has had to make a completely fresh start. It was not a simple matter of finding equipment and personnel and clearing the débris from airfields. In 1945, when the final count was taken, the cost of the war to Japan was found to be: nearly a million-and-a-half troops and civilians killed; 30% of the urban population rendered homeless; 40% of the urban area razed to the ground; a reduction in industrial capacity to one-third of the 1936-1937 level and a reduction in territory of nearly half its former size.

Reconstruction and rehabilitation were hampered by the return of millions of repatriates from former overseas territories, severe food shortages and spasmodic political strife. The War severed Japan's lines of trade. In the 16 months ending December, 1946, the country's total exports amounted to a mere $103 million, little more than 5% of the 1955 figure. The World trade recession during the immediate post-war period added to its difficulties. Even had it been otherwise possible, Japan at that time was in no economic shape to re-establish its commercial air traffic.

In 1945 the Potsdam Declaration of the Allied Powers minced no words when it referred to the future of Japanese aviation. Japanese companies or individuals, it read, were prohibited for an indefinite period from manufacturing, operating or owning aircraft of any kind. One of General MacArthur's first tasks as Supreme Commander for the Allied Powers was the implementation of this ruling. Equipment and ground facilities which had survived bomb damage and deterioration



A map showing the development of Japan Air Lines' network from 1952 to 1958. Aomori, Nagoya and Hiroshima are now served by All Nippon Airways Co.

from disuse were either requisitioned for the Occupation Forces or methodically destroyed. With the exception of the Air Navigation Office, all government departments connected with aviation affairs were ordered to be closed down. The Civil Aeronautics Board was abolished. The ban on air activities was so complete that it had almost a psychological effect. Many of Japan's leaders in aircraft production and air transportation were convinced they would never again be active in their fields.

However, although a long occupation had, at first, been foreseen, World events soon caused a radical change in the policies of the Allied Occupation, spurred on by the United States Government. Demobilization and demilitarization were so speedily accomplished and political trends evidenced such an amazing degree of democratization that, as early as 1947, the American Government urged the negotiation of a peace treaty—but met strong opposition from Russia. Thereafter, the speedy and complete rehabilitation of Japan's economy became a major objective in American policy.

Probably, the event which gave the greatest initial impetus to the rebirth of Japanese aviation and, subsequently, its air transportation, was the outbreak of the war in Korea in June, 1950. The urgent need for a constant flow of United Nations airborne manpower and materials through bases in Japan necessitated an overall improvement and extension of ground facilities of every kind. Runways had to be extended and strengthened, modern radio aids installed. Maintenance facilities and fuel capacities had urgently to be multiplied. The U.S. Air Force gave enormous overhaul and maintenance contracts to the large Japanese aircraft companies such as Mitsubishi and Kawasaki, which had thousands of experienced aircraft workers available. The training and experience gained from the U.S. Air Force at this time by Japanese engineers, communications and handling staff undoubtedly played a big part in speeding up the re-establishment of Japan's civil aviation.

The necessity of launching the United Nations offensive from Japanese soil made Japan's non-sovereign status an increasing embarrassment. In 1951, therefore, it was decided to abandon attempts to conclude a joint peace treaty with the participation of all Second World War belligerents and in September of that year, 48 nations signed the treaty with Japan, Russia abstaining.

Six months previously, the Japanese Government had been authorized to license an airline for internal services provided that no Japanese national took part in the "development, manufacture, assembly, ownership or airborne operation of civil aircraft." It says much for their spirit and confidence in the future that this devastatingly restrictive condition failed to dissuade the country's transportation, industrial and financial leaders from pressing for the speedy formation of a national airline company. In fact, at a public hearing in Tokyo in the spring of 1951, as many as five different groups submitted their plans for developing domestic air traffic. Finally, the licence was granted to the group representing the embryo Japan Air Lines Company headed by Aiichiro Fujiyama.

It is not surprising that Fujiyama's group was the final choice of the Commission. He had the moral and financial support of Ichiro Ishikawa, chairman of the Japan Economic Federation; Shinichi Hayakawa, president of the Nippon Express Company; Ryutaro Takahashi, chairman of Japan Chamber of Commerce; Giichi Murakami, president of the Kinki Railways Company; Ataru Kobayashi, Governor of the Development Bank; Shinsuke Asao, president of Nippon Yusen Kaisha (N.Y.K. Line); Takeo Saito, former vice-president of the pre-war Japan Air Lines and Michisuke Sugi, chairman of the Osaka Chamber of Commerce—a powerful and representative cross-section of Japan's commerce and industry.

The first problem confronting the new company was the choice of a foreign carrier to operate its services, in compliance with the Allied Powers' restriction. At one time Fujiyama favoured a joint operation by all foreign airlines then serving Japan—Northwest Airlines, Pan American Airways, Civil Air Transport Canadian Pacific Airlines and Philippine Air Lines. However, obvious difficulties arose because of the competitive positions of each of these companies, and this plan was dropped. PAA offered to be responsible for the supply of all equipment and crews in exchange for the right to buy a 50 per cent. interest in the company. But this proposal was turned down on the grounds that acceptance of such a large proportion of foreign capital would be detrimental to the long-term interests of the Japanese economy. Finally, an agreement was concluded with Northwest Airlines for a one-year lease on equipment and crews and the supply of aircraft maintenance services.

The first flight, by a Martin 202, was inaugurated on October 25, 1951, along the route Sapporo-Tokyo-Nagoya-Osaka-Iwakuni-Fukuoka, running the length of the Japanese islands from north-east to south-west, thus linking Tokyo with the political seats of Hokkaido and Kyushu Islands, Sapporo and Fukuoka, respectively, and the principal provincial business centres. Figures for the first complete year of operations, 1952, showed that 102,955 revenue passengers were flown over a total of 2,013,533 kilometres to produce a passenger load factor of 76.7%. The comparative figures for 1953 were: 211,528 passengers, 3,129,137 kilometres flown and 70.5% load factor.

A few months after the restoration of scheduled domestic services, two more companies came into being to supply an increasing demand for special flights—Japan Helicopter Transport Company and Far East Airlines. Both of these had one eye on the possibility of obtaining certification to fly in competition with J.A.L. on domestic or overseas routes. Traffic developed so favourably for these companies that, by November, 1954, they were both permitted to operate scheduled passenger flights as feeder lines running in parallel to J.A.L.

(*Continued on page 567*)

A panoramic view of the runways and new terminal buildings at Tokyo International Airport, Haneda, with the waters of Tokyo Bay in the background.

Seven aircraft of the Japan Air Lines fleet are visible in this picture, including two DC-6Bs in the foreground and DC-4s beyond.

(*Continued from page* 566)

internal routes. Last year they merged to form the All Nippon Airways Company and have plans for a considerable improvement and expansion of local services. Apart from a variety of light, single-engined aircraft, this company operates D.H. Herons and Doves, Handley Page Marathons and DC-3s. It would be an excellent potential market for a British twin-engined, 15-21 passenger transport.

The 18 months which followed the ratification of the Peace Treaty in April, 1952, saw Japan's complete return to active participation in international air affairs and commerce. The government passed the Civil Aeronautics Act in July, 1952, and this gave impetus to the long-delayed conclusion of bi-lateral air agreements with various other countries, including the United Kingdom, which took place during the ensuing months. Although B.O.A.C. have been operating into Japan since then, J.A.L. does not anticipate taking advantage of its return traffic rights until 1960 when the delivery of new turbojet aircraft will ease its equipment situation.

In 1952, also, the government Civil Aeronautics Bureau was set up under the Ministry of Transportation and immediately began its task of supervising aircraft registration, air safety, aircraft maintenance standards, training and licensing of crews, airport facilities and the operating and commercial standards of foreign carriers serving Japan. The C.A.B., apart from its other tasks, is now also responsible for search and rescue operations. These are organized with the joint co-operation of the Maritime Safety Board, Police Board, Defence Agency and municipal authorities. Close contact is maintained with the U.S. Far East Air Forces.

Simultaneously with the creation of the C.A.B., a government Civil Aviation College and Technical Research Institute were set up under the direct authority of the Minister of Transportation. Full training facilities were provided to qualified students wishing to make a career of commercial flying. Many of these are now in command on internal flights and taking intensive training for international captaincies.

The problem of supplying adequate and expert maintenance services for the up-to-date equipment ordered by J.A.L. was solved by the formation of an engineering company in Tokyo, jointly owned by J.A.L., Northwest and Transocean Air Lines and known as Japan Aircraft Maintenance Company. American personnel of Northwest and Transocean supervized the work of Japanese engineers. This has since expanded into a large concern which undertakes outside contracts also. In addition to overhaul and maintenance, the company is licensed for the modification of aircraft, engines and other equipment.

Although the odds were in their favour, Japan Air Lines, after a year of successful internal operations, were far from certain that the government would grant them certification for international routes. Also, Pan American Airways had not given up hope of obtaining a substantial interest in the Japanese flag-carrier and were sponsoring a company known as Japan American Airlines with strong industrial and political support. K.L.M. sided with yet another group. Nevertheless, the government decided in favour of J.A.L. and, on October 1, 1953, the company was reorganized and freshly incorporated to provide for new financing. One half the capital investment of two billion yen was supplied by the government. The other half came from the insurance, financial, steamship and travel agency groups who were the sponsors of the original company. With this all-important issue finally settled and out of the way, J.A.L.'s management were able to proceed immediately with their plans for the start of international flights.

Options on three DC-6Bs were hurriedly taken up, flight crews were seconded from Transocean Air Lines, Japanese girls who had never before seen the inside of an aircraft were initiated in the techniques of handling air passengers by a senior hostess of United Air Lines, technical and operations experts were begged, borrowed and sometimes stolen from other airlines. For some time, a special staff of translators was engaged on no task other than the word-for-word translation of ICAO and IATA manuals into Japanese. Only one month after their designation as Japan's overseas flag-carrier, J.A.L. had a delegation of senior sales executives and tariff experts in attendance at the annual traffic conference meeting of IATA convened that year in Honolulu. Their membership of the Association had been made effective only a few weeks previously.

J.A.L.'s first international operation was inaugurated February 1, 1954, and consisted of two flights in each direction per week between Tokyo and San Francisco via Honolulu and Tokyo and Okinawa. Each succeeding year since then has seen an extension of frequencies and routes. Today the Tokyo-San Francisco route is operated daily in each direction with DC-7Cs. Scheduled flights are made also to Okinawa, Hong Kong, Bangkok and Singapore and to Sao Paulo via San Francisco and Caracas. Four DC-8s are on order for delivery in mid-1960 and these are intended primarily for the lucrative trans-Pacific route. By 1960, also, J.A.L. expect to be competing on the well-beaten track to Europe via India, using Paris and London as terminal points.

It is interesting to analyse how J.A.L., with the odds at the outset seemingly loaded against it, managed within the short space of four years to make such a highly successful operation out of its international services, measured in terms of both financial profit and national prestige abroad. When J.A.L. commenced its overseas flights world trade was suffering from a pronounced recession, trans-Pacific airline traffic was at its lowest ebb, modern equipment was hard to find and expensive and the Japanese Government was exerting the utmost pressure for the exercise of economy (1953 showed an adverse trade balance of $1,134 million). To add to these discouraging factors, J.A.L. knew it would be not only competing with large, long-established companies on their home territory, but facing the possibility of unchangeable sales resistance in the general public abroad due to a lasting hangover of resentment or prejudice. However, J.A.L. realized also that it could expect to carry much of the government-sponsored traffic originating in Japan and would have little difficulty in selling space to families of Japanese origin living in Hawaii and California.

While even the Japanese themselves would be the first to agree that some part of their success in the airline industry is owed to foreign technical and financial assistance, most of it is undoubtedly due to wise forward-planning, courageous spending and imaginative selling. The manner in which J.A.L. has followed these principles might be studied with profit by some larger airlines, some of whose costs grow at a much faster rate than their traffic. J.A.L. has never sacrificed profit to prestige by over-extending itself, but has concentrated heavily on the money-making route, disregarding line extensions until it felt the market was ready for entry. With the aid of its government (not always easy to obtain), J.A.L. has insisted upon keeping pace with technical advancements, using Japan's limited dollar reserves to finance better equipment as soon as it became available.

It has adopted a tone in its advertising and promotional

material which exemplifies oriental aestheticism and dignity. Like ju-jitsu, a seemingly mild and gentle sales approach can often have a devastatingly successful effect. Furthermore, J.A.L. has actually done much to create new passenger traffic by discreetly publicizing the native arts and folklore of Japan in close co-operation with government trade and travel bureaux abroad. This campaign has been so successful and western hemisphere interest in the orient has been aroused to such a degree that some 154,000 visitors are expected in Japan this year, according to the Pacific Area Travel Association—an increase of 20% over 1957.

In Japan, corporate or company flying is not yet practised to any great extent outside of the newspaper field. Nearly all of the major Japanese newspaper companies operate fleets of aircraft which range from light, single-engined types and helicopters to light, twin-engined executive transports. Japanese newspapers have always played a leading rôle in maintaining public interest in aviation and, between the two World Wars, sponsored several long-range pioneer flights.

In addition to J.A.L. and All Nippon Airways there are more than 20 charter companies in Japan, 10 of which are authorized to operate non-scheduled passenger flights. Most of their contracts are for photographic and geological surveys, fish-shoal detection and light cargo transportation.

Japanese whaling fleets have found the helicopter an invaluable aid in increasing the size of their catch. Helicopters are now considered standard equipment for the fleets that set out for the Antarctic each year.

Foreign airlines have been operating to Japan since the early days of the Allied Occupation when Pan American Airways and Northwest Airlines aircraft were used as U.S. Military Air Transport Service transports. From 1952 onwards foreign airline interest in services to Japan increased rapidly and 12 now operate frequent scheduled services to Tokyo: Air France, Air India International, B.O.A.C., Civil Air Transport (Formosa), C.P.A.L., K.L.M., Northwest, P.A.A., Qantas, S.A.S., Swissair and Thai Airways.

Tokyo International Airport at Haneda, 12 miles from Tokyo city centre, was completely rebuilt two years ago. It now handles about 150 international flights per week excluding those of M.A.T.S. The new three-storey terminal building has an interesting design which permits a passenger to alight from his car directly in front of the handling office of his airline. All the airline processing is completed just a few steps away. With an annual increase in traffic of some 30%, plans for the extension of Haneda figure very prominently in the future of Tokyo. During the next three years, 300 acres of Tokyo Bay will be reclaimed to permit the construction of a new runway 9,600 ft. long. The two runways currently in use are 8,400 and 5,500 ft. long respectively.

Largely because of the great use made of Haneda by M.A.T.S., American Air Force personnel are still in charge of air traffic control. For some time past, however, Japanese staff have been undergoing on-the-job training and will soon take over control of all civil air movements.

For a country whose economic position has been, and still is, far from secure, the support which Japan has given to the re-creation and development of its air transportation is something to be admired. Certainly, apart from the financial return, it has yielded dividends in the re-establishment of friendly relations abroad and with a speed that no amount of verbal platitudes and diplomatic visits could have equalled. Next year, eight years after the creation of his airline, Seijiro Yanagita, president of J.A.L., will take office at the annual general meeting of IATA to be convened in Tokyo, as that Association's president. The World's airlines have chosen a fitting manner in which to recognize Japan's new status in the field of air transportation.

A New National Carrier In Europe

EUROPEAN air transport, with its well established pattern, does not often see the establishment of a new national carrier. This rare event did take place on March 31 when Austrian Airlines flew inaugural Vienna-London-Vienna services.

The young Republic's entry into the highly competitive business of airline operation will be a gradual one. Initially services are being operated with four Viscount 779s chartered from Norway's Fred Olsen. In view of the wish to start services at the earliest possible date, this was no doubt the wisest course. Although charter rates must inevitably be high the cost is known and the lengthy build-up period of training is avoided.

The duration of the Olsen charter is understood to be 26 months and from this it would be reasonable to expect that a decision on new equipment will be made before the end of 1958. In the meantime the Austrians will be able to assess the market. Their present preference inclines towards the Viscount 810, which offers competitive performance plus the ability to fit into the operational pattern now being established with the 779s. Besides the daily service to London now in operation, services are proposed to Zurich, Frankfurt and Hamburg. Later the network will be extended to include Paris, Rome and Warsaw.

Vienna has long been a great surface communications centre and, with 18 airlines serving the city, it is an increasingly important centre for air transport. If and when the European free trade area comes into being Vienna has been named by some as a likely administrative capital. This together with an increase in East-West trade and communications could well, in time, justify Austria's new airline, the stockholding of which is held 70% by nominees of the two major Austrian political parties and 15% each by S.A.S. and Fred Olsen.

The day-to-day management of the line is under the direction of joint managing directors—Sepp Froeschl (technical) and Rudolf Trimmel (commercial). Captain P. Bergsland, formerly Olsen's chief pilot, now holds a similar appointment with Austrian Airlines and has with him 16 other Olsen pilots. All these crews now have Austrian nationality. A training programme has been under way for some time and Austrian-born pilots are coming along. For the ground organization a number of Olsen "A" and "C" licensed engineers are in Vienna to supervise maintenance and to train specialist Austrian ground crews. For the present, to ease the load on an extremely young organization, a large British aircraft maintenance concern will carry out checks 3 and 4. The airline, as is usual, is well backed by resident technical representatives of the airframe, engine and ancillary manufacturers.

Austrian Airlines advertise themselves as "The Friendly Airline" and if the inaugural flights are a criterion they will soon earn the title. Whilst realizing that they will always be outside the big league of the major operators they have stated their determination to learn to provide high standards of service for their travelling public. The cabin of Viscount 779 must be one of the most pleasant in service with Viscount 700 operators. Forty-eight passengers are carried four-abreast; the toilets are positioned forward, in the plane of the propellers, with the galley aft. A seat pitch at 34 in. and an aisle width of 18.5 in. (24 in. above the floor) provide a good standard of comfort for regional operation. The London-Vienna run is a three-hour flight.

Altogether, to find an airline in embryo in Europe in 1958 is a fascinating situation. The beginnings are small but anyone who has seen the Austrian programme of reconstruction and public works will be aware of their ability to tackle big jobs.

K.L.M. Tourist Bookings

FROM K.L.M. we have received an interesting breakdown of offered capacity and bookings on their westbound services to New York in April and May, following the introduction of economy-class travel on April 1. Like the majority of airlines on the route, K.L.M. is retaining some tourist seats (we inadvertently conveyed that they were not in our March 28 issue), but well over half the total of seats offered will be economy class.

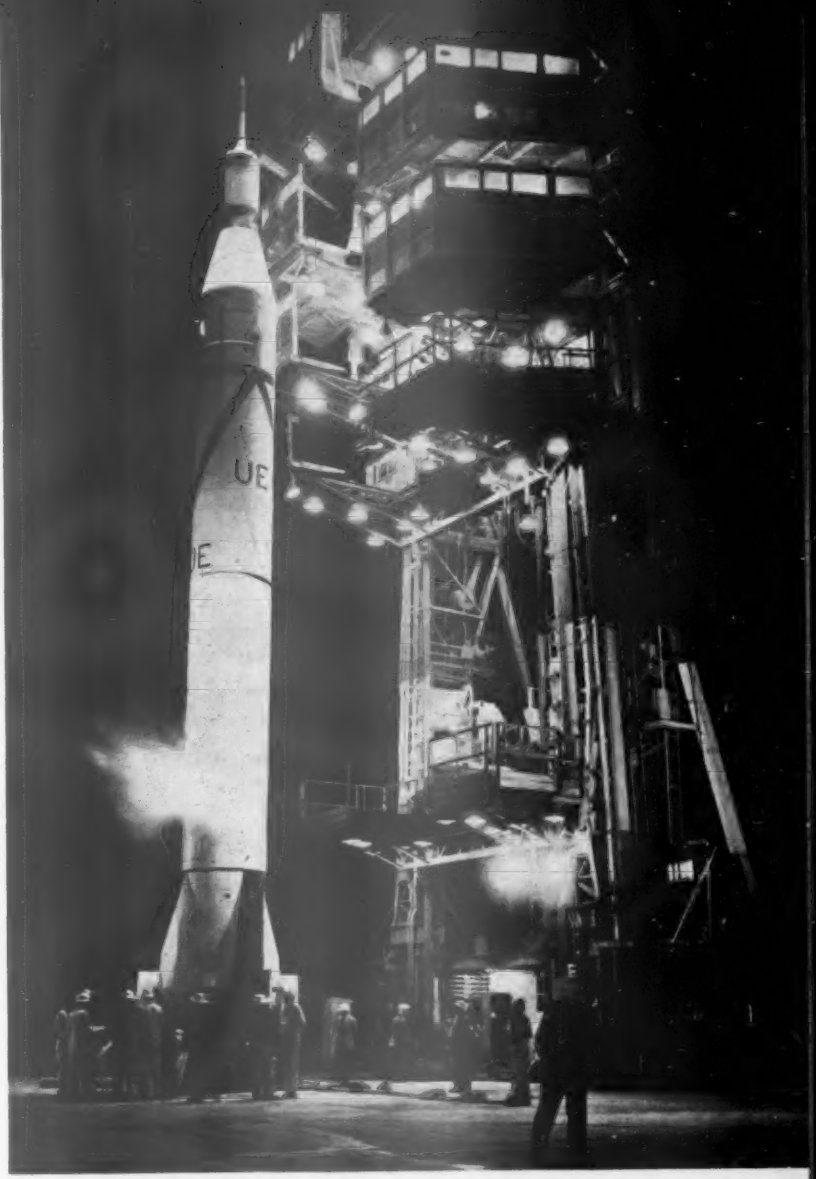
This month the division of seats is 9% de luxe, 6% first-class, 24% tourist and 61% economy. Advance bookings for April were made up of 12% de luxe, 12% first, 35% tourist and 41% economy, but these are not, of course, final figures.

For May, the capacity is divided 8% de luxe, 5% first, 20% tourist and 67% economy. Bookings for this month so far are in the proportions 5%, 7%, 30% and 58%. The continuing interest in tourist-class travel is interesting—and is higher, percentage-wise, than has been reported by some other operators.

Missiles and Astronautics

The Satellite Story

By James Strong,
B.Sc.(Eng.), A.C.G.I., A.F.R.Ae.S.



The U.S. Army's Jupiter C, carrying the Explorer earth satellite, on the launching pad prior to firing at Cape Canaveral.

SIX MONTHS have sped by since the first man-made satellite was hurled into an orbit round the Earth, to circle there above the atmosphere for three months before spiralling inwards to destruction. As a feat of technical skill it will rank for all time in the annals of scientific achievement, though whether the event constitutes the dawning of a space age—as many claim—is still open to question. Is the claim any truer now, or was it a false dawn?

The moment seems opportune to review in retrospect what has taken place in the interim, and so try to estimate the quality of success—perhaps even attempt to divine what the future holds for mankind.

One thing seems plain enough. Whilst the rest of the World looks on, two great military powers, the Soviet Union and the United States of America, openly vie with one another to be the first to fly in outer space. Ultimately—and maybe sooner than expected—one of them will succeed. The race is on, and the stakes high. Both now regard satellites as expendable pawns, opening moves in the grim game of international politics with World prestige the prize. The quest for scientific data becomes almost secondary to such considerations. Yet one day it may be a matter of life or death to some courageous pilot risking his life to ride the thin frontiers of space. Let us pray that he will return in safety.

Things move fast in this pre-era to a dawning space age, if such it be. At this moment three separate satellites (and a disused rocket-motor casing from the latest Vanguard launching) are following their ordained paths through space at between 12,000 and 18,000 m.p.h. Before this is in print they may have been followed by others, for the placing of an object into a reasonably stable orbit has turned out to be not so difficult as was once imagined, barring false starts. From the variety of orbits so far attained, some of them far from circular, the laws of celestial dynamics seem to permit of quite a fair tolerance.

Project Orbiter versus Project Vanguard

Although mainly of historical interest, it is a fact that the launching of earth satellites was first discussed seriously in 1954, following proposals put forward by British scientists earlier in 1951. A scheme, known as Project Orbiter, was prepared by the German rocket engineer, Dr. Wernher von Braun, who proposed using as the first stage a 75,000-lb.-thrust Redstone missile, with clusters of solid-propellent Loki rockets for the subsequent stages. It was hoped by these means to put a 5-lb. satellite into orbit, following it up with more ambitious satellites if the first proved successful.

Work started on the scheme, with the approval of both the U.S. Army and Navy. But it was suspended the following year whilst the Pentagon considered whether to go forward with an idea that meant diverting military effort.

Meanwhile, the Project Vanguard proposals in connection with the International Geophysical Year had been steadily drawing attention in different quarters, and it was obvious that if they were approved there would be duplication of effort. Project Orbiter was therefore shelved, even though it had progressed in design to a point almost identical to the Jupiter-C configuration later resurrected when the Vanguard developed trouble. Had Project Orbiter been allowed to continue there is little doubt that American satellites would have been circling

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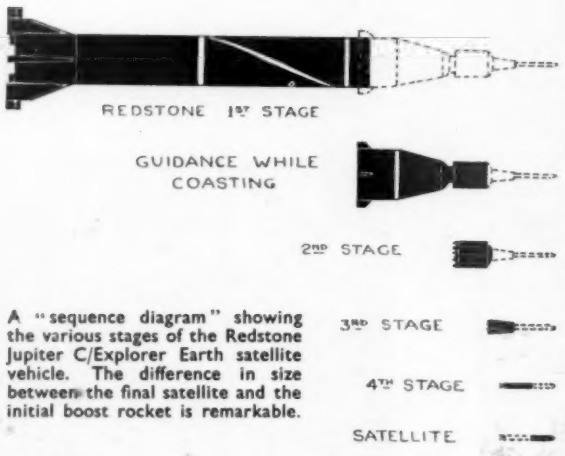


A "sequence diagram" showing the various stages of the Redstone Jupiter C/Explorer Earth satellite vehicle. The difference in size between the final satellite and the initial boost rocket is remarkable.

the Earth in the summer or autumn of 1957, as scheduled.

The story of Project Vanguard has already been told (in particular in THE AEROPLANE for June 28, 1957) in detail. It began in October, 1954, when one of the Committees of the I.G.Y. recommended that ". . . serious considerations should be given to the launching of artificial satellites during the Geophysical Year, together with their instrumentation, the telemetering of scientific data whilst in orbit and the reception of these data at strategic points around the Earth." Eventually, in July, 1955, two years before the start of the Geophysical Year, the order to begin was sanctioned by President Eisenhower.

The object of the Vanguard Project was to launch a 21-in.-diameter sphere, containing scientific instruments, batteries and short-wave transmitters weighing 21 lb., into a 300-mile orbit. To do this, one of the U.S. Navy's Viking research rockets, suitably lengthened, was to be used as a first stage, surmounted by a second-stage liquid-fuel rocket containing a guidance system to programme the path of the latter to orbital height. The third stage was to be a solid-propellent rocket, to the forward end of which the satellite would be attached and released at the conclusion of burn-out. The entire design was meant to be a civil project, under the supervision of the Martin Co., Baltimore, who were themselves the designers of the Viking research vehicle.

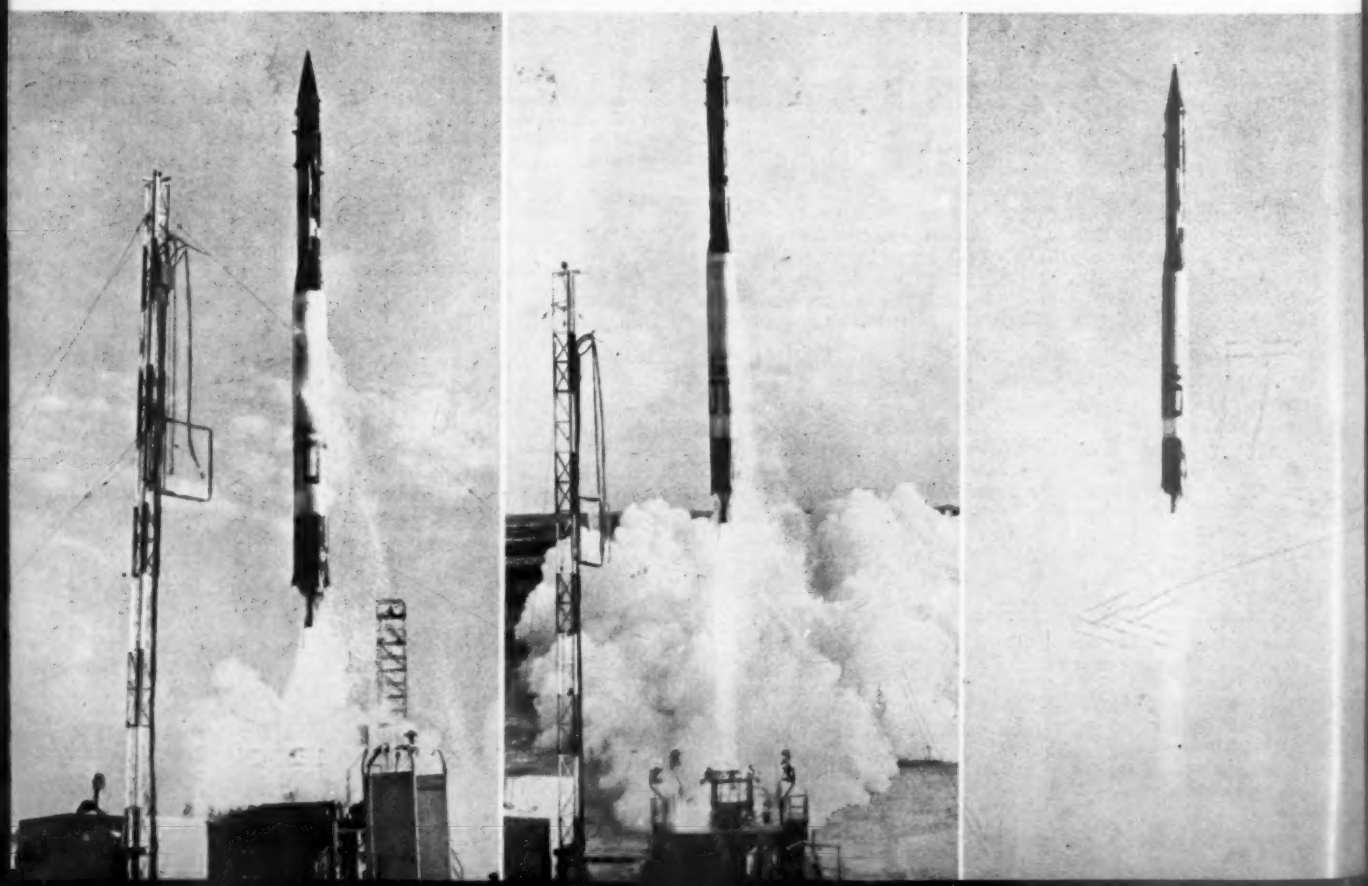
Almost complete details of the Vanguard construction were released to the public from the beginning, and the project bathed in the fierce light of publicity to such an extent that it was forgotten that rockets are notoriously unreliable when first built. To design and develop the satellite vehicle in two years (the I.G.Y. began officially on July 1, 1957) was a tremendous task, and those who know the idiosyncrasies of missile engineering were not surprised when test firings were put back month after month. Some of the early shots with first- and third-stage components showed high promise, but there were rumours that troubles had appeared.

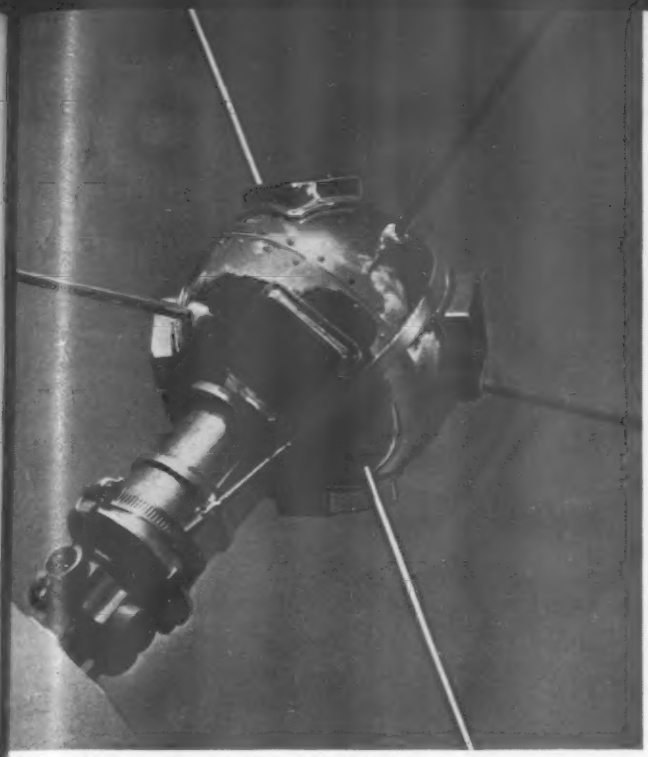
The initial firing date was eventually put back to the late autumn of 1957. There was even talk of postponing it altogether until early 1958, when cable and radio stations burst on the air with news that the Soviet Union had already launched a satellite into space.

The Sputniks

Announcement by Soviet radio stations on the night of October 4-5 that a Russian satellite was at that moment orbiting the Earth was sensational. Russian prestige zoomed to ionospherical levels as from every quarter of the Globe came the familiar "bleep, bleep" of the satellite's transmitters. As a display of technical achievement the news was staggering; all the more so because, though Russia had announced that she would join with the United States in sending up satellites during the I.G.Y., the statement had been brushed aside as mere propaganda. Politically the repercussions were immense as

A sequence during the first successful firing of the U.S. Navy's Vanguard rocket which put America's second satellite into orbit.





The Vanguard satellite, 6½ in. in diameter, atop the third stage of the vehicle which put it into orbit; note the rectangular solar batteries, on the surface of the sphere, which power the radio transmitters.

the World listened, heard and understood the significance of the Soviet "Sputnik."

Proof that the Soviet Union was well advanced in the technology of ballistic missiles could no longer be denied. Since 1955 American radar operators, stationed in Turkey and Iran, had been keeping the Soviet IRBM launching site east of Stalingrad under constant surveillance. From the Elburz Mountains, and the 10,000-ft. peaks north of Meshed, giant radar bowls had been staring down on the Soviet missile range stretching from Krasnaya, on the Volga, due east for 1,400 miles to Lake Balkhash.

But although they could track the Soviet IRBMs, and count their successes and their failures, the size and thrust of the Russian missiles remained a mystery. It has been suggested that to launch the heavy Sputniks the Russians used for their first stage the T3A, a modified ICBM, 125 ft. high, engined by two 228,000-lb.-thrust motors and having an all-up weight of around 150 tons. The second stage, it is then thought, might have been a T-1, a 77,000-lb.-thrust missile, not unlike the German V.2 or a Redstone Jupiter.

To obtain for their satellite a near-polar orbit (65° to the Equator), the Russians launched the rocket north-east. Second-stage separation must then have taken place over thinly populated, low-lying land north of the Caspian, followed by third-stage control high over the Urals west of Sverdlovsk. From there the satellite vaulted swiftly over the entire Siberian continent (ideally suited for telemetry tracking) to pass out into the Pacific somewhere near the tip of Kamchatka. Traversing the Pacific Ocean from north to south, the satellite passed over Graham Land, in the Antarctic, before turning north again over the South Atlantic, crossing Africa on its homeward flight to the Soviet Union again. Around the World in 96.2 minutes!

When the announcement was made it was given out that the satellite was an aluminium sphere 22.8 in. in diameter and with the surprisingly heavy weight of 184 lb. At first this was thought to be an error, and when the Soviet Union insisted that the weight was correct there was some scepticism. The suggestion has been made that this figure includes not only the satellite, but the weight of the burnt-out rocket casing of the third stage and the nose cone, which were also in orbit. The truth has never been revealed.

Very soon it became obvious that Sputnik I's signals were being modulated, and that it was, in fact, transmitting scientific data of some sort—probably temperatures and micro-meteor impact measurements. At least four modulated signals were being sent.

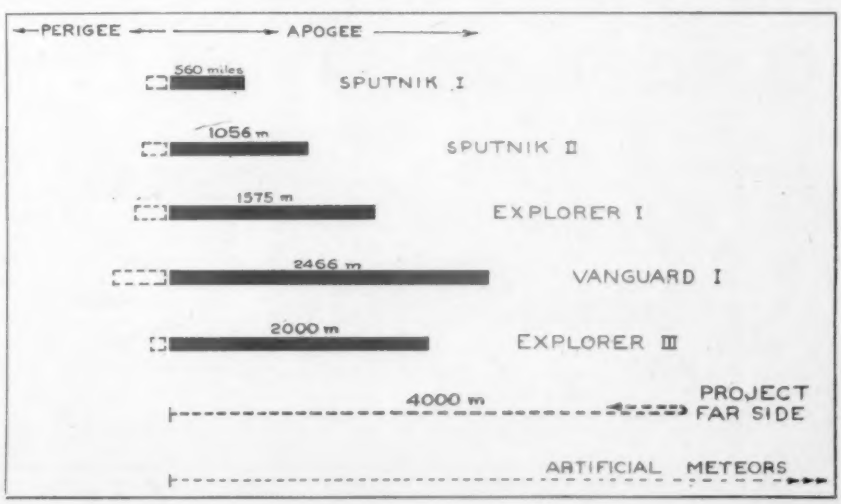
Tracking the satellite proved to be relatively easy, despite the fact that, though the Vanguard tracking stations were designed to operate at 108 megacycles, the Soviet satellite transmitter frequencies were 20.005 and 40.002 megacycles, necessitating hurried conversions.

In Britain, the great 250-ft. steerable radio telescope at Jodrell Bank, though not completed, was quickly brought into use. Hectic work, night and day, amidst paint, scaffolding and indifferent weather, was crowned with success and the telescope brought into operation and the satellite tracked by radar.

From early sightings it had been calculated that Sputnik I had an apogee of 560 miles and a perigee (lowest point to the Earth's surface) of 145 miles. As time went on the apogee decreased steadily whilst the perigee remained little altered. The orbital period became less and less. The rocket casing, being larger and heavier, had spiralled lower and, therefore, faster, getting ahead with each revolution until it lapped the satellite, a paradox that was predicted by celestial mechanics. But after three weeks the batteries powering the transmitters were exhausted, and its position could only be checked by photographic sightings or by radar.

Meanwhile, in the United States, Professor Kraus, radio astronomer at Ohio State University, had observed that whenever the satellite or the rocket casing passed overhead a streak of ionization in the atmosphere was bouncing back radio signals from his transmitter. He concluded that the satellite was behaving like a super-meteorite, and that it was relatively simple to determine when it was passing in the vicinity.

In this way he was able to record the decreasing period of revolution as the rocket casing entered the atmosphere. The critical period turned out to be 87½ minutes, and 60 days after



Since artificial satellites first began to be launched their orbits have steadily increased in diameter. The apogee (farthest distance from the earth's surface) of the first Soviet Sputnik was 560 miles, giving it a total orbital diameter of 8,635 miles. The U.S. Vanguard satellite ranges over four times as far into space, with a total orbit of 10,820 miles.

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launching the rocket casing vanished. Its probable fall was somewhere in the Pacific.

Of still greater interest was the fall of the satellite itself. On January 4, Kraus saw three separate ionization bursts where only one had been expected, as though the satellite had broken into several pieces, each possessed of a differing aerodynamic drag. On January 5, the bursts increased to five in number, and on the following day to eight. By then the satellite was scattered over a distance of 8,000 miles in space, and pieces were falling with different velocities.

By January 8, four pieces had disappeared; on the 9th there was only one left, and on January 10 the last trace had gone. Sputnik I had completely disintegrated. It had circled the Earth for 97 days and had travelled a distance of several million miles.

Sputnik II

Whilst Sputnik I had continued to circle the Earth, and radio announcers had been monotonously recording the number of orbits and the distance travelled *ad nauseam*, the Russians had, unbeknown to the World, a further ace up their sleeve. On November 3 they produced it; they launched their second satellite.

Once again the World was staggered, for the new satellite was even bigger and heavier than the first, and to the astonishment of everyone it was announced that it carried a live dog. Sputnik II, said the Soviet scientists, weighed half a ton and, in addition to the dog (which was sealed into an airtight, air-conditioned container), instruments in the satellite monitored its heartbeats, respiration, blood pressure and temperature.

There were also instruments for recording ultra-violet and X-ray radiation from the sun, and cosmic-ray counters. But these seemed relatively unimportant compared to the medical data being collected from a living animal subjected to the regime of space flight.

A storm of protest went up from dog-lovers all over the World and the Soviet Union lost a good deal of initial prestige despite the fact that the use of animals by both the Soviet Union and America for high-altitude rocket research had been known for some while. Possibly this was excused by the safe return by parachute of previous animals, and it was hoped that the Soviet scientists had found some way of bringing an orbiting satellite safely back to Earth.

For three days all news from the Soviet Union ceased to all intents, as though they had forgotten the satellite they had just sent up. Rumours circulated to the effect that attempts were being made to slow the satellite by firing recoil rockets, and that these had proved unsuccessful. Meanwhile, signals from Sputnik II had died away after only three days, and the Russians then reported that the dog had died—but not without purpose for it had provided them with valuable data.

Sputnik II continued to circle the Earth for 23 weeks to the day. It disintegrated during the night of April 13-14 over the Caribbean.

Aluminium Meteors and Balloon Busters

Though the Americans did not have the satisfaction of launching the first satellite into space, they had been busy on other matters. In October, 1957, they fired an Aerobee to a height of 54 miles, and from there blasted into the atmosphere aluminium pellets. Photographs subsequently showed at least two artificial meteors created in this manner, glowing as brightly as Jupiter and travelling at 33,000 m.p.h. As the velocity of escape from the Earth's gravity is 25,000 m.p.h., it is surmised that some of the pellets left the Earth altogether and went into an orbit round the sun.

The Sputnik launchings were also responsible for hurrying on another scheme known as Project Far Side, which was an attempt to shoot a 3½-lb. payload of instruments 4,000 miles from the surface of the Earth. Project Far Side was a four-stage rocket, weighing 1,900 lb., which was to be lifted to a height of over 100,000 ft. by a Sky Hook balloon and fired vertically upwards. Trials were to begin from Eniwetok Atoll, in the Pacific, but the programme was dogged by bad weather and bad luck from the start.

On October 3, the first vehicle was fired. It ripped through the balloon, as expected, but the telemetry was damaged and data only recorded up to 500 miles. Four days later the second was launched from 70,000 ft. due to cold weather in the stratosphere. Some of the stages failed to fire, and the transmitter itself went dead at 400 miles.

On October 11, the balloon froze in the tropopause, but on October 20 the rocket reached 4,000 miles, based on visual observations of the firing period, though telemetry was intermittent. The sixth and last launch took place two days later. It is thought that this, too, reached 4,000 miles, though the transmitter failed again at 1,000 miles. No further firings are planned at present.

Jupiter C and the Explorer

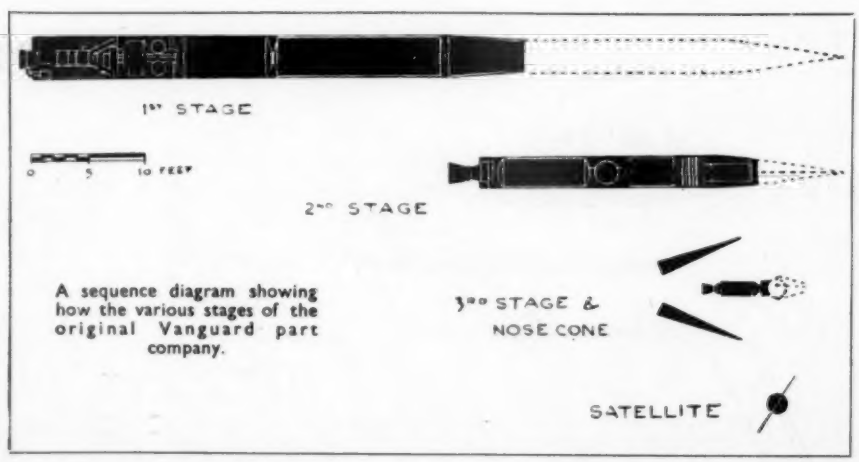
After the Russians had launched their two satellites the United States, very naturally, strained every muscle to follow suit. Immense pressure was put on the Vanguard crews to prepare for an early launch, despite the troubles that had manifested themselves. It was not until December 6, nevertheless, before the Vanguard vehicle was ready. Its publicity build-up had been tremendous, and this in itself was unfortunate for it served to increase the anti-climax when Vanguard rose a few feet from the launching pad, only to fall back in a welter of smoke and flame.

The United States citizenry were stunned by the disaster and U.S. prestige took another dive. The immediate reaction of the Americans was an even greater determination to succeed and, largely as a result of the fiasco, the United States poured money and material into a space programme far greater than she would otherwise have bothered to follow.

A further Vanguard was ordered to be readied, but to back it up the U.S. Army was told to resurrect Project Orbiter and put it into readiness at an early date. Fortunately its designer, von Braun, had continued quietly to progress the instrumentation of the satellite in collaboration with the Jet Propulsion Laboratory of the California Institute of Technology.

It had been planned to use a Redstone vehicle as the first stage, but to increase the tankage and, therefore, its overall length. Above the guidance compartment of the Redstone there was attached a "bucket" containing the second-, third- and fourth-stage solid-propellent rockets. These were in

(*Continued on page 573*)



A sequence diagram showing how the various stages of the original Vanguard part company.

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(*Continued from page* 572)

concentric clusters, with the central one carrying the satellite instruments. The purpose of the " bucket " was to impart spin to the three-stage configuration, so as to even out instability during the firing period.

The satellite itself weighed 18¼ lb., of which the instruments were 11 lb., though complete with burnt-out rocket casing the entire mass scaled 31 lb. The satellite, 80 in. long and 6 in. diameter, contained two transmitters with a power of 10 and 60 milliwatts.

Jupiter-C was successfully launched into a stable orbit on January 31, 1958, and, being the first satellite for the year 1958, it was given the astronomical designation 1958 Alpha. Its orbit proved to be even greater than Sputnik II, with an apogee of 1,575 miles and a perigee of 230 miles. It is, therefore, fairly certain to have a long life, though radio transmissions may last for only two-three months.

Research in Space

The instruments carried in the Explorer are intended to measure three things: cosmic-ray intensity above the ionosphere, micrometeorite distribution, and the temperature of the satellite itself. This data was to be relayed continuously by coded modulation of a high-power radio transmitter on a frequency of 108.03 megacycles for a period of two-three weeks. A second, low-power transmitter will continue to broadcast the same information on 108 megacycles for two-three months.

The Geiger tube with which the satellite is equipped is of the type that keeps a count of the number of cosmic-ray particles that penetrate and trigger its detectors. It will transmit a code signal whenever a total of 32 particles have been counted, repeating the signal when the next 32 particles have been detected, and so on.

Thus, the intensity of the cosmic radiation is a measure of the time interval between two consecutive signals. This, in turn, can be related to the satellite position, its latitude, longitude and distance from the Earth's surface—all of which are known once the orbit equation has been established. It is not expected that a continuous record of all signals will be kept, or even possible, but a special watch will be kept whenever a solar flare is reported so that records may be linked with any magnetic disturbance that may follow.

Distribution of micrometeoric dust particles around the Earth will be measured by recording the frequency and energy with which they strike the satellite, producing vibrations in the skin adjacent to a flush-mounted crystal microphone. Variations in the size of the dust particles will be detected by the amount of acoustic energy picked up and amplified for transmission by the satellite's radio link. Very little is yet known as to the density and relative scatter of these dust clouds, which stretch beyond the orbit of the Earth and give rise to the phenomenon known as zodiacal light.

In addition to this, a number of resistance-wire erosion gauges have been stuck to the outer skin of the Explorer. It has been estimated that, at the satellite's speed of 5 miles a second, particles 5 microns in diameter (0.0002 in.) or larger will break the wires on impact. Unfortunately, some of these gauges do not appear to have survived the launching phase of the ascent and have already snapped, due, no doubt, to vibration caused by rough motor burning.

The temperature of the satellite, internally and externally, is being measured at four points by small thermocouples. These have been placed on the skin, inside the nose cone on a probe and in the centre of the transmitter package. Their temperature-sensitive resistance will vary as the satellite passes alternately from the full glare of the sun's radiation into the depths of the Earth's shadow during each revolution.

It is also anticipated that certain long-term changes will occur as time goes by, due to alteration in the skin emissivity under the continual bombardment from dust particles. Temperature measurements are one of the vital pieces of information required before manned flight in outer space can be contemplated.

There were two excellent reasons for choosing such a high frequency as 108 megacycles for the Explorer's radio transmitters. First, it makes use of the dozen " Minitrack " satellite tracking stations already set up and tuned to follow signals from the ill-starred Vanguard satellite. And, secondly, compared to the 20- and 40-Mc/s transmission of the Russian Sputniks, it was hoped that the higher frequency would not be so affected by fading or refraction through the ionospheric layer, thus enabling the Explorer's true position at any given moment to be fixed with greater accuracy. (In practice, however, this did not prove to be the case and fading was experienced.)

Use is also made of the Doppler frequency shift of the signal to measure the satellite's speed relative to a ground station. Special " Microlock " detecting stations were set up in Florida and at San Diego, California, which picked up the satellite at the conclusion of its first orbit. Two more stations, operated by British teams, are sited at Ibadan, in Nigeria, and at Singapore.

Unfortunately, the Explorer comes no nearer to the British Isles than North Africa, due to the shallow inclination of its orbit to the Equator. The B.B.C.'s listening post at Tatsfield has succeeded in picking up its signals, but it is unlikely that the Jodrell Bank radio telescope, previously used as a giant radar to track the Sputniks, will be diverted for the same purpose from its programme of galactic research.

It is too early yet to say what information about the ionosphere and exosphere will be revealed, though all the data will be made available to countries participating in the I.G.Y. If the low-power transmitter batteries last for 10 weeks, as it is hoped, the high orbit of Explorer will certainly confirm atmospheric temperatures and density farther out into space than have ever been measured before.

It will also be interesting to see whether the data coincides with the surprisingly high atmospheric density values at an

Some idea of the scale of the Vanguard's satellite is given by this photograph of the sphere being installed on the third stage prior to fitment of the nose cone. The satellite weighs 3¼ lb. and is 6½ in. in diameter.

altitude of 140 miles suggested by the rate at which Sputnik I slowed down. This was five times greater than expected, and presumably as the drag is proportional to the diameter and mass of the object this should confirm the weight of Sputnik I, which has been such a contentious subject.

The Grapefruit Satellite

The second Vanguard launching fared little better than its predecessor when, on February 5, it was fired from Cape Canaveral. After the first-stage motor had been firing well for a minute and the Vanguard had climbed to 20,000 ft., the airframe buckled and broke in two and crashed out to sea.

At the third attempt, on March 17, the Vanguard vehicle behaved perfectly, and a small test satellite weighing only 3¼ lb. was placed into a high orbit. The satellite itself was quite the smallest on record, being little larger than a grapefruit, but contained two transistorized transmitters connected to a bristling array of six aerials. A novel feature in its construction was the fitting of half a dozen solar batteries. These could draw energy from the sun whenever they faced it and supply power for the smallest transmitter for an unlimited time, or until erosion dulled the surface of the windows.

The Vanguard satellite was shortly followed by a second Explorer which, for some reason, failed to transmit and was, therefore, lost. It is thought that one of the rocket stages refused to fire. Explorer III was recently launched into a highly eccentric orbit that is not expected to last for long.

Messages from Space

It is pertinent to ask whether the scientific world has learned much from the five satellites that have gone into orbit. The answer would appear to be—not very much. Results have certainly been obtained, but these have only confirmed earlier estimates or revealed discrepancies. Which were right? The basis of scientific logic is that an experiment must be repeatable and, due to the spasmodic nature of the data and varying conditions, this became impossible. Barely 3% of the information transmitted by the satellites has been picked up.

The Soviet Academy of Sciences has sent in to I.G.Y. headquarters a "Preliminary Report on the First and Second Artificial Satellites" that adds little to what is already known. The results are still being analysed, and it appears that during its 23-day radio transmission the first satellite suffered no damage and survived two major meteor showers.

Estimates of the atmospheric density above 200 km., based on the weight and frontal area of the Soviet satellites, have proved surprisingly high and somewhat inconsistent. British ionospheric observations were confined to analysing the intensity and variation of the received transmissions, as well as estimating the orbital constants by interferometer and Doppler techniques. These were soon accurately known. Their records even revealed that Sputnik I was spinning slowly at seven times a minute.

Within a few hours of launch information from Explorer I gave the internal temperature as 30° C., and a cosmic-ray count of 32 had taken place (which was expected). The incidence of a major solar flare 10 days after Explorer I had gone into orbit raised hopes that some valuable information would be picked up. Unfortunately, the more powerful of the two transmitters had by then ceased to function and the smaller was swamped by ionospheric disturbances. And, as already mentioned, the choice of a high frequency (108 Mc/s.) did not prevent fading, as anticipated, and there was no tape recorder on Explorer I to permit data playback when conditions improved.

Missile to the Moon

Without a doubt the launching of further satellites may be expected in the near future, and it is even more certain that they will become increasingly sophisticated. With Sputnik II having spiralled inwards it is generally believed that Soviet scientists are preparing for some big event. They may attempt to hit the moon, or at least achieve a near miss.

Whether hitting the moon with a missile constitutes a step forward into space is controversial. For all we know it might precipitate an interplanetary war which, to say the least, would be unfortunate.

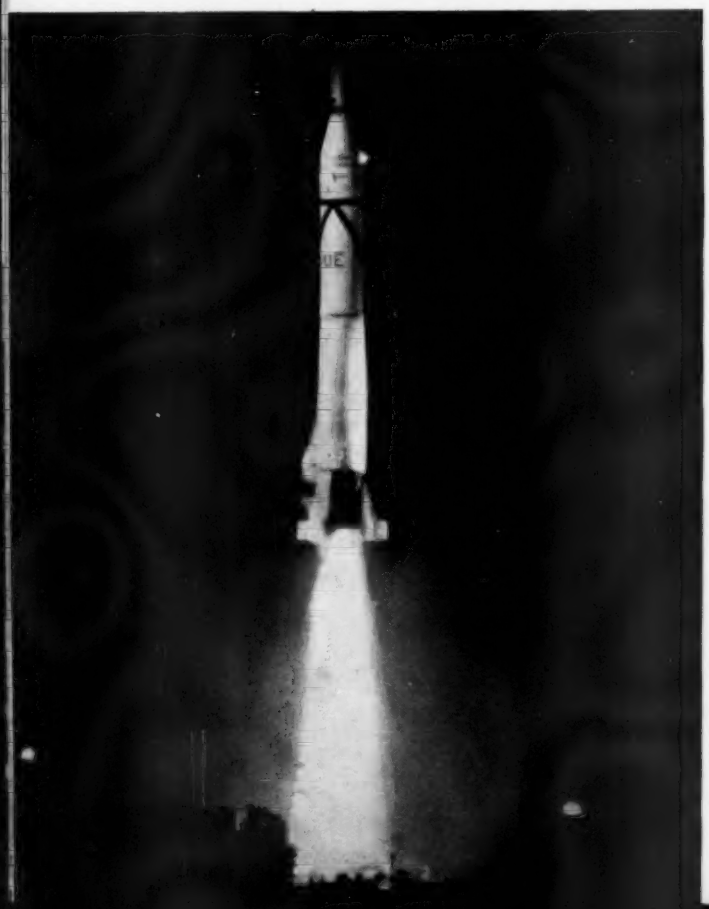
Any attempt to reach the moon will meet with prodigious technical difficulties. First, it will probably entail the placing of a large carrier satellite in orbit and then, at some split-second instant, necessitate the launching of a series of rocket stages in a very precise direction by remote control. A direct hit on the moon would involve observing a magnesium flash or the explosion of a dye-marker that would discolour the surface. Considering the general ruggedness of lunar terrain, the point of impact would not be too easy to recognize.

The Americans are also full of plans. Schemes for "lunar probes" are being discussed, and though no timetable has been advanced it has been reported that at least five attempts will be made. The U.S.A.F. are said to be planning to reach the moon by using a Thor IRBM, and either the second and third stages of Vanguard or the Lockheed X.17 as a carrier vehicle.

With greater likelihood of success is Pied Piper, a plan to launch a reconnaissance satellite into orbit, converting a Thor rocket for the purpose, and later attempting to recover the satellite in some manner. This could be a worthwhile step that might lead to a fully manned satellite at some future date.

Nor should we think only of the efforts being made by the two great powers, for the United Kingdom must one day take to space. As Marshal of the R.A.F. Sir Dermot Boyle said recently, writing in THE AEROPLANE on the 40th Anniversary of the R.A.F., ". . . One of these days I think we shall see the manned vehicle . . . sooner or later . . . which can reconcile the concepts of the supersonic bomber and the manned satellite . . . and I believe, too, that this country cannot afford to stand aside from all part in their development."

This, then, is the future in which, whether we like it or not, we must take part.



Jupiter C/Explorer getting away to a fine start.

Missiles and Astronautics . . . .

Paths in Space

THE BODIES which the Russians and the Americans have projected into space have become, in their rapid and almost frictionless courses, subject to the laws of celestial mechanics like other heavenly bodies. The path of a satellite, whether natural or artificial, is governed by gravitational attraction whose magnitude can be informally stated as being proportional to the product of the mass of the bodies and inversely to the square of the distance between them; a graduate of Trinity College, Cambridge, who reads latin can see the formal statement there in an original copy of "Philosophiæ Naturalis Principia Mathematica," by Sir Isaac Newton, of 1686.

Newton who established that the forces between spheres acted as if from their centres, showed that the paths of bodies controlled by these forces were conic sections, and that the path of a satellite was elliptical. So that the Moon, the Sputniks, Vanguard, and Explorer, all travel in elliptical paths; the velocity of Sputnik I was stated to be 18,000 m.p.h. and of Explorer to be 19,500 m.p.h. while the velocity of the Moon is 2,300 m.p.h.; as the Moon is at a greater distance, the force of attraction and the curvature of its path are correspondingly reduced.

The velocity of a body at any point in an elliptical orbit is:—

$$v^2 = C\left[\frac{2}{d} - \frac{1}{a}\right]$$

where v is velocity in m.p.h.; C is a constant, of 1.25×10^{12}; d is the distance from the centre of force in miles; and a is the major semi-axis.

The greatest height of Explorer, its apogee, has been stated to be 1,700 miles and its minimum height, the perigee, to be 200 miles. This gives a velocity of 13,600 m.p.h. at the former position and 18,700 at the latter. The variation in velocity is caused by the increase of potential energy as the satellite travels away from the Earth against the force of gravity with a corresponding decrease of its kinetic energy and this change is reversed when the satellite returns. In its frictionless path the total energy, the sum of these two, is constant.

The same principle holds in the launch of a satellite, if the basic problem is considered first and the resistance of the atmosphere is neglected during the fraction of the path which lies within it. Imagine a satellite meteorite which strikes the Earth travelling at its orbital velocity; then a body projected with equal and opposite velocity would traverse the same orbital path.

If the meteor had not been in an orbit round the Earth but had come from outer space, it would have arrived at a greater velocity, and this is called the velocity of escape. This is the velocity which will carry a body outside the gravitational field of the Earth—or, in other words, to infinity.

At any point on the escape path, the gravitational attraction which acts on a body is:—

$$g_d = g\frac{r^2}{d^2}$$

where r is the radius of the Earth; d is the distance of the body from the centre of the Earth; g is the value of gravity at radius r; and g_d is the value of gravity at radius d. The work done by gravity on the body during its passage to infinity is:—

$$\int_r^\infty Mg\frac{r^2}{d^2}\,d(d) = Mgr$$

where M is the mass of the body. This is equal to the kinetic energy of the body on striking the Earth. For the velocity of escape, then:—

$$\frac{1}{2}Mv_e^2 = Mgr$$

where v_e is the velocity of escape.

A body travelling round the Earth in a circular orbit (the effect of the atmosphere still being neglected) at the altitude for which the velocity of escape is considered, has an acceleration normal to its velocity equal to the acceleration of gravity, so that:—

$$\frac{v_c^2}{r} = g$$

$$\text{so that } v_e = \sqrt{2}\,v_c$$

where v_c is the velocity for a circular orbit.

Thus the velocity of escape at a given radius from the centre of the Earth is the velocity for a circular orbit at that radius multiplied by $\sqrt{2}$, that is, say, increased by 41%, and this result is general for any radius from the centre of the Earth.

An artificial satellite sustains losses while it is accelerating under propulsion and while it is passing through the atmosphere. These two main losses are the retardation of gravity during the propulsion period, and the resistance of the atmosphere.

The effect of gravity is apparent when watching the take-off of a rocket. The ascent, for example, of a V2 was impressive and deliberate; and while the rocket engine gave a thrust of 25 tons, and the weight was about 13 tons, half the thrust only provided acceleration which at first was only $0.9g$. As the rocket ascended, the weight decreased as the fuel was burnt, the thrust of the engine increased somewhat as the density of the atmosphere decreased, so that an increasing proportion of the thrust of the engine provided acceleration. In the case of the V2, the acceleration at the end of propulsion immediately before engine shut off had risen to $5g$; so that a proportion of thrust varying from one half at the beginning to one sixth at the end of the propulsion period had been spent in overcoming gravity and had not contributed to the velocity.

So long as the initial thrust is comparatively low, the problem of air resistance is ameliorated for the density of the atmosphere decreases with height, and the drag which is proportional to the density and to the square of the speed is held down if the velocity is moderate during the first part of the flight. (The drag coefficient in supersonic flight is taken to vary with the speed.)

To give established figures again, the V2 reached an airspeed of M=1 after 25 seconds of flight, perhaps in the region of 16,000 ft. altitude where the density is about 0.6 of its value at sea level. Dornberger also mentions that an airspeed of M=2 was reached at over 30,000 ft. so that the atmospheric density (which is 0.35 of sea-level value) was greatly reduced before half the maximum speed of the rocket had been reached.

For this actual performance, no general and elegant mathematical solution, as for the space path, is possible; detailed knowledge of the engine characteristic, fuel consumption, aerodynamic shape and its drag, are needed when the velocity at any time is given by:—

$$v_t = \int_0^t \frac{P}{M}dt - \int_0^t g\,dt - \int_0^t \frac{a}{M}dt$$

in which all symbols are variables, as follows: v_t is the velocity at time t; P is rocket thrust at time t; M the mass at time t; g the gravity at time t; and a the aerodynamic drag at time t.

Published figures for the orbit and speed of Explorer do not quite agree with the velocities which are given above, and no full statement has been seen at the time of writing. The orbit which has been stated seems rather low; while the density of the upper atmosphere is not known, estimates indicate that there is an appreciable density at 200 miles which is the height given as the perigee of Explorer's orbit, and a satellite descending to that level would be likely to be noticeably retarded, and the duration of its voyage would be shortened. Now that the President of the United States has said that full information of the results would be given, it will be interesting to see whether a more circular orbit was intended with a greater minimum height and a slight shift in the guidance system has occurred, or whether observations at that altitude were desired and the path is being achieved as planned.—"KENTIGERN."

Missiles and Astronautics . . . .

The World's Guided Weapons

In this article "KENTIGERN" *surveys the guided weapons that figure in the current production and development programmes of a number of countries. He divides his thesis into three main parts—dealing first with the British weapons and then going on to discuss those of other countries with smaller programmes. His third section reviews American and Russian guided weapons activities together.*

THE UNITED KINGDOM

DESPITE the restriction of information by Security, the pattern of United Kingdom Guided Weapon Defence is now becoming apparent. The air-to-air weapon is the first to be brought into use, and this is closely followed by the ground-to-air defensive weapons. An American intermediate-range ballistic weapon is to be adopted while we are developing a "hard" weapon for the same use; and there is to be a guided bomb for use by the V-bomber force. In military doctrine, a war is won by attack, and therefore the ballistic weapon and the guided bomb are the primary weapons—which will be dealt with in the chronological order listed above.

U.K. Defensive Weapons

Operational problems of the air-to-air weapon are complex and it must be considered in its place as part of the whole defensive system. Some of this system may be common to the fighter-borne air-to-air weapon and the ground-launched surface-to-air weapon.

The vital quantity—the time which is available for the interception—depends on the depth of the radar screen and on the speed of the enemy bombers. If the enemy be armed with self-propelled "stand-off" bombs, the time for the interception is reduced, and the distance from the target at which the interception must be made is increased. The short time from the moment of detection of the enemy to the moment when the interception must be completed before the bomber arrives within reach of the target is easily spent.

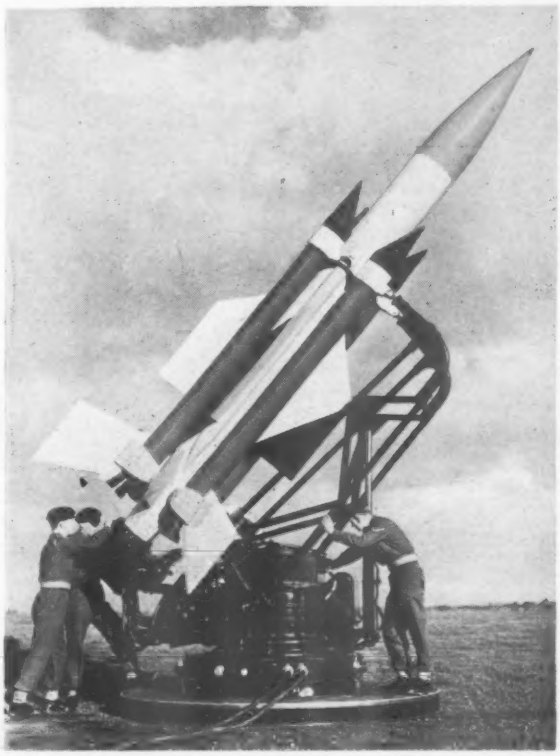
First there must be radar detection, then recognition to distinguish between enemies and friends; this must be followed by time for the commander's decisions. Then the fighter pilot must start his engine and get into position and take-off; and this is followed by the time of the flight and of any manœuvres before interception is made.

A valuable saving of time is given by the ability to attack the oncoming enemy head-on. If the air-to-air weapon has to be fired from astern of the enemy, there may be a stern chase which is proverbially long. Moreover, the fighter may naturally

On April 8 the mobility of the R.A.F.'s Bristol-Ferranti surface-to-air guided weapon was demonstrated when two of these missiles and their handling trolleys were transported in a Beverley of Transport Command from Filton to Cranwell.

be placed to make a head-on attack on the oncoming bomber, and if this is impossible, the fighter must be turned. At high speed and high altitude the minimum radius of turn is large and as the closing speed of the two aircraft is something near Mach 2, the time to start the turn will be critical. It will then need most accurate ground control, for the two aircraft may not be in sight of each other; any delay in starting the turn will put the fighter a long way behind the bomber when the turn is finished.

On the other hand, the head-on attack is a difficult condition to meet, for the firing fighter at modern closing speeds will have little time to avoid collision unless the weapon has a long range; and the problem of finding the enemy at long range and locking on the homing system must be technically difficult. For these considerations, the capability of an air-to-air weapon of making a head-on attack is an important factor in its operational performance.



In production for the British Army and on order for the R.A.F. the English Electric Thunderbird forms part of a complete weapons system developed by the company's Guided Weapons Division at Luton and Stevenage.

The Fairey FIREFLASH, the first weapon to pass its acceptance trials and to be put into service, is a beam rider. The pilot aims the radar beam onto the target by aiming the aeroplane with a normal gunsight, and when he fires the weapon it is boosted to its full speed by external boosts which separate when expended. Receiving beam signals, the weapon then centres itself in the beam and coasts along it until its fuse is triggered by the target.

Such a weapon can only be used for attacks from the rear, for the radar beam could not be held on the enemy while he was approaching in a head-on attack if collision were to be safely avoided. It was found impossible, too, for the fighter pilot to make a beam attack and to turn with the enemy even at the comparatively moderate speeds of fighters in the late War.

De Havilland's FIRESTREAK is in production for the R.A.F.

The third large British surface-to-air weapon is Armstrong Whitworth's Seaslug which is in production for the Royal Navy. This photograph taken at last year's S.B.A.C. display shows its fin and booster arrangement.

and for the R.N. but has not yet officially been stated to have passed its acceptance trials. Unlike the Fireflash, it has an internal motor and so may be propelled for the greater part or for the whole of its flight. The guidance is by an infra-red homing head, but no information on the performance of this head, or whether it can home on any parts of the enemy aircraft other than the hot jet pipe seen from behind, has been published. Unless the head has the capacity to home on other parts of the target, the fighter will here again be restricted to a stern chase and an attack from the rear.

On the other hand it is difficult to see how the enemy could practise any form of "infra-red warfare" on the lines of the "radio warfare" practised in the late War and which is sure to be practised again. When the infra-red eye has engaged the target, there are no obvious ruses that the target can use to deflect it.

Firestreak, therefore, may be restricted to making attacks from astern, but in this attack is likely to be resistant to countermeasures. As it is a homing weapon, the fighter will be free from the moment of launch, having no need to aim a beam or give any form of control, and the pilot can immediately manœuvre and look out for enemy fighters.

The Vickers-Armstrongs RED DEAN, development of which was stopped in June, 1957, was a larger weapon, 16 ft. long, for air-to-air use and was intended to be used with all-weather fighters such as the proposed thin-wing Javelin. The contract for this fighter was cancelled and so was Red Dean.

Thus, the United Kingdom air-to-air programme consists of Fireflash which is in service with a Swift squadron (there is no mention of its being in service in Hunter squadrons) and Firestreak which is stated to be intended for use with the P 1b, Javelin, Sea Vixen, and the now-cancelled Saunders-Roe SR-177.

Ground-to-air weapons are developing close behind the air-

Right, the Martin Matador TM-61C surface-to-surface weapon is operated from a zero-length launcher mounted on a transporter truck.

Missiles and Astronautics . . . .

to-air weapons, they are already undergoing trials and they are more important for they have been chosen as the eventual main defence of the United Kingdom for the future, against bombers. The two types for land-based use both use semi-active homing which implies that ground radar transmitters are used so that the weapon can home on the echo from the enemy aircraft. These radar transmitters must be suitable for both weapons if expensive duplication is to be avoided.

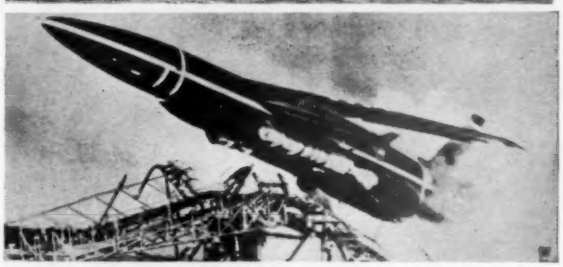
As in the case of the air-to-air weapons the same system time study is needed, but the time is consumed here, after the radar and command delays, in the delay in firing the weapon. The weapon may be cold, or there may be a stand-by state in which it can be held for long periods.

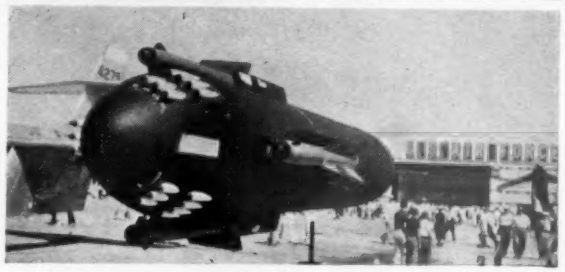
Opinions have been given that the next major war may be over in a few days, perhaps in a few hours, but this cannot be assumed in the design of the weapon which must be able to remain in the stand-by state without deterioration, if it is impossible to fire it quickly from cold. When ready to fire, there is no more delay for the launcher can direct it towards the bomber, and the boosts give an acceleration that will bring it near to cruising speed in a few seconds.

The interception task of the surface-based weapon is easier than for the fighter/weapon combination. Suppose that it is locked on to the bomber before firing, it can home directly from that moment, aiming off for the quickest path as its computer calculates, and using a proportional navigation system described in recent papers before the Royal Aeronautical Society (although there may be a system which is better still). The weapon can make a head-on attack, being indifferent to its own fate! And the use of proportional navigation makes a beam attack possible, for it gives a path which "aims off" so the weapon is flying towards a point which is ahead of the bomber and the weapon is not turning, or is only turning slightly in the final stages of the interception.

The characteristics of the weapon then determine its success in killing the enemy. No determination or skill on the part of the crew can affect the result after it has been fired, though judgment in the operational command is needed to direct the weight of the defence against the most dangerous attacks. The interesting point is that essential ingredients in the success of the defence are the brains and skill and energy deployed on the design and production of the weapon. The engineering work has advanced a step to a point where it is more important than ever before.

This point is made because once the weapon has been fired,





Top to bottom, de Havilland Firestreaks on a Sea Vixen for the Royal Navy; a Northrop Snark "taking-off" from its zero-length launcher; and an armament pod on a U.S.A.F. F-89 Scorpion carrying rockets and four Falcon guided missiles.

and is intercepting the target on an economical course, its success depends on its lethality which depends on the miss distance achieved by the guidance and control system combined with the lethal radius of the warhead. The miss distance depends on the detail design of the radar, controls, and aerodynamics of the weapon.

Armstrong Whitworth's SEASLUG is the weapon for the Royal Navy. It is a beam rider like the first weapon for the United States Navy. Its range has not been given, but its dimensions are larger than those of the U.S. Navy weapon and thus may indicate that its range is greater.

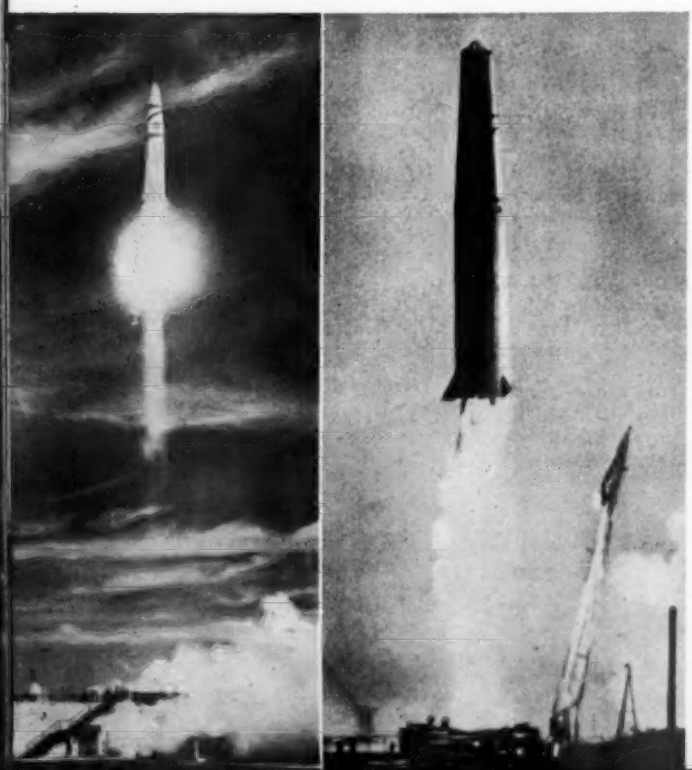
The Bristol BLOODHOUND is in production for the Royal Air Force. It is said to be intended as the standard U.K. defence weapon and to have a range greater than 40 miles. Launched by boosts, it is propelled by ramjets so that an optimum range is available in the propulsion as it can be extended by providing a greater fuel load. Its speed has been reported as Mach 2.5 so that it can catch any present bomber in a stern chase should that ever be necessary.

Great Britain's other surface-to-air weapon is the English Electric THUNDERBIRD, which is in production for the Army, and is also for the R.A.F. Like the Bloodhound it is launched by four solid-rocket boosters but it is propelled subsequently on its course by a long-burning solid rocket.

Both these weapons are stated to be in production, but neither has yet been officially stated to have passed its acceptance trials.

Before dealing with the more important ballistic weapon, the minor projects can be briefly discussed here. After all the trouble which was given by the excellent German tanks in the late War, and in view of the high quality of Russian tanks, it is

(*Continued on page* 579)



Two versions of the U.S.A.F.'s Thor intermediate-range ballistic missile. The one on the right has a blunter nose cone for research into the re-entry problem.

Missiles and Astronautics . . . .

(*Continued from page* 578)

curious that the comparatively easy task of making a small short-range anti-tank weapon was not undertaken for some time. The result is that the most fully developed weapon seems to be the Australian MALKARA of which a film of a remarkably accurate flight through a target has been shown. In England a new development by Vickers-Armstrongs—the TYPE 898—has been announced; and also there is the Short Brothers and Harland surface-to-air weapon for shipborne use.

A project which the U.K. has not undertaken at all, so far as published information can be relied on, is the ground-launched flying bomb. This is interesting because the LARYNX, perhaps the first practical weapon of this type, was developed successfully by the Royal Aircraft Establishment in 1927 but was not then adopted by the R.A.F. We experienced the same type of weapon in 1944 in the form of the V.1; this was of simple construction, its production put little load on the German aircraft industry, and its maintenance was not onerous.

If the V.1 had been ready only 13 years after the Larynx it could have been launched in 1940 and 1941 when our defences were fully extended. A.A. Command could not have been redeployed to deal with it, there was little or no effort to spare in Fighter Command to intercept it, and Bomber Command could not have attacked the launching sites so effectively as it was able to do when the weapon actually appeared. It seems then, that the V.1, if launched at an earlier date, might have made a troublesome and perhaps a dangerous attack.

There is no information, either, on any anti-submarine guided-weapon system—although our survival in both World Wars depended on the defeat of the submarine siege. The Russian submarine fleet is strong compared with the German pre-war fleet, and the use of nuclear propulsion will eliminate the need to spend time in a vulnerable state on the surface, so the problem is now more serious.

The pilotless target for exercising guided weapons and also anti-aircraft artillery is itself an elementary form of guided weapon. Methods of design for aircraft for this purpose are well established, stemming from the Fairey Queen and Queen Bee of the late 'twenties and early 'thirties and there is now a conversion for the METEOR so that it can be flown as a pilotless target. In Australia, the JINDIVIK has been designed for this use with a Viper turbojet engine. There are also several French and numerous United States aircraft for this purpose.

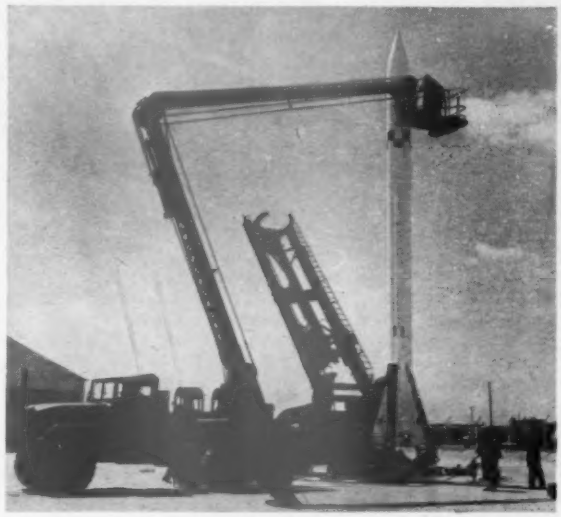
U.K. Deterrent Weapons

Finally there are the primary weapons, the guided bomb for the use of the V-bombers, and the ballistic weapon.

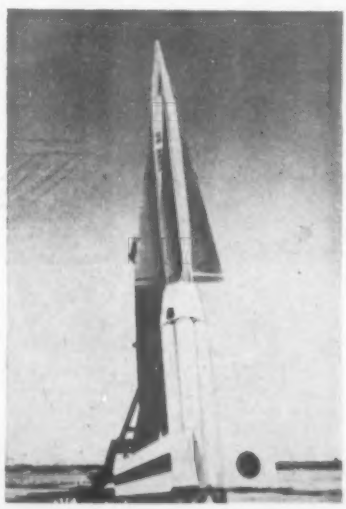
The guided bomb, or stand-off bomb, is being developed by Avro, and no direct information has been given about it, but something can be inferred from official statements. It has been said that it can be "released outside the enemy defences." This must mean that it has a minimum range in self-powered flight of 500 nautical miles if it is to be released outside the frontier defences of an enemy country. It would not seem to be an accurate statement if it meant only that it could be released outside the local defences of the target, which would need a range only a tenth as great.

The guidance system is not mentioned; a radar system would allow the accuracy of the bomb to be independent of the accuracy of navigation of the bomber, but the range would be great so that the countermeasures working at short range would have an advantage in power at the receiver. Inertial navigation can also be made independent of the navigation of the bomber, but the long duration of the flight causes the requirement for accuracy to be severe.

First ballistic weapon for the use of Bomber Command is the Douglas THOR, which is dealt with later with other United States weapons. The United Kingdom weapon announced last year but not yet named is to have a range of 2,000 miles and to be launched from underground sites so that it is resistant to enemy attack and can be used as a reply. While the characteristics of the U.K. weapon cannot, and perhaps should not, be estimated, a good idea of its general characteristics can be gained from the family of similar weapons under development in the U.S. for a somewhat smaller range, 1,500 miles, which are mentioned later.



An artillery missile, the Corporal is a short-range (about 100 miles) ballistic weapon. Under the American missile agreement with this country weapons of this type are being supplied to the British Army.



The latest version of the Douglas Nike surface-to-air missile is Nike Hercules. It has a single solid-propellent sustainer rocket and a cluster of four tandem booster units.

FRANCE, SWITZERLAND, ITALY AND JAPAN

Other countries which are developing guided weapons are France, Switzerland, Italy, and Japan and there is the Australian anti-tank weapon mentioned above.

France is developing the most complete range of guided weapons as shown by the tables on pages 591-593. For example, there are two air-to-air weapons, both of which have a single solid-rocket motor designed to give a high thrust for the initial boost and to continue burning with a sustained thrust for propulsion. The 5103 is a command guidance weapon, the aircraft transmitter giving pulse signals designed to allow several aircraft to operate their own weapons without interference and also to resist jamming. The MATRA guidance is given as "optical" which is probably some form of infra-red homing.

An air-to-surface weapon, the B.B.10 is believed to transmit a telemetered picture of its view to the aircraft from which it is controlled by command link. France has four surface-to-air weapons, PARCA which depends on radar tracking of target and weapon, and command link for guidance (the system of the U.S. Nike which is discussed later); the 4300 whose method

Above, left, Fairey Fireflash beam-riding air-to-air missiles installed on a Hunter 4 for trials purposes. Above, right, is a Saab-32 Lansen carrying two Swedish-developed Type 304 air-to-surface missiles.

of guidance, progress, and range has not been stated, and the naval weapons MARUCA and MASURCA.

There is also the 4200, a command link surface-to-surface weapon whose range is 60 miles, and a naval ship-to-ship weapon whose range is not disclosed, nor any other particulars. It is believed that the naval weapons are for the primary defence of ships, and Parca is believed to be in production. There are also two French wire-controlled anti-tank weapons.

Oerlikon in Switzerland has developed two ground-to-air beam-riding weapons of which the earlier has a range of 12 miles. The later model which is an improvement of the same system has had speed increased from M = 1.8 to M = 2.3, although the range may not have been greatly increased for the weight is slightly reduced. Contraves of Switzerland have developed an anti-tank weapon with wire guidance.

For Italy, Contraves have developed an air-to-air weapon with infra-red homing. There are two surface-to-air weapons, the A.R. 15 by Motofides which may be a preliminary development for a larger weapon, and the M.R. 27 which is stated to have performed satisfactorily under radio command, and to have " intermediate " range.

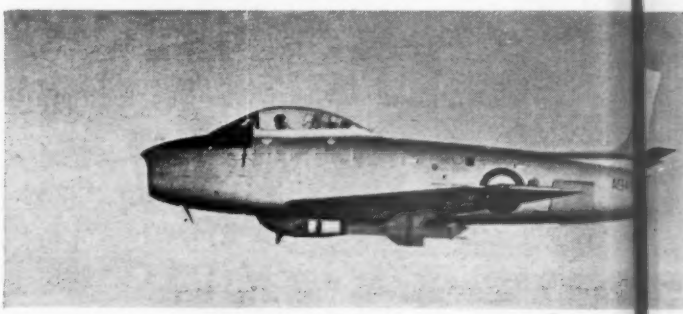
Lastly there is Japan where Mitsubishi is developing two air-to-air weapons, one weighing only 45 lb. and one of more normal weight, i.e. 235 lb. Also in Japan, Kawasaki is developing an anti-tank weapon but no particulars have been given.

Of these four countries France, and possibly Switzerland could base a defensive system on their own weapons; and France has the 60-mile tactical weapon and anti-tank weapons for army use.

RUSSIA AND THE UNITED STATES OF AMERICA

Comparison of Russian and United States progress, the most important comparison that can be made, is hindered by the lack of information from Russia even more than by U.S. security. The democratic form of government in the United States at least feels the pressure of public opinion and the desirability of disclosure when this is reasonably possible.

The Russian list shows very few types, but this may not be a sound guide to the variety of their development work nor to the breadth of their experience by a comparison with the number of types of weapon disclosed by the U.S. The Russians with their bureaucratic organization will tend to list only weapons which are accepted for general introduction and to avoid any tendency to admit to competition or parallel development in their organization. Thus the public appearance of a



weapon can be taken to show that the type of weapon system has been thoroughly explored and that any necessary variety of preliminary trials has been done. The benefits of centralized mass production are also sure to have been fully achieved.

Organization in the United States on the other hand, is a contrast to this. First, the three Services, Navy, Army, and Air Force are themselves in competition and each of these has in some instances put in orders for more than one weapon for a single rôle. Co-ordination at a later stage has sometimes led to arrangements for a weapon which has been successful in trials to be used for another Service in addition to its original sponsor. An example of this is Talos produced originally for the U.S. Navy and now to be used also by the Army.

There is only a single Russian air-to-air weapon listed; this is shown to be approximately 8 ft. long and 9 in. in diameter which puts it among the smaller air-to-air weapons. It is propelled by a solid rocket and the guidance system is not mentioned.

Compared with this, there is an encouraging amount of information from the United States. The U.S. Navy has, in effect, four air-to-air weapons. There is the RAYTHEON, SPARROW 1 with beam riding, a SPARROW 2 is mentioned without more information and SPARROW 3 with active radar homing; the speed of Sparrow is given as M = 2.5. Another weapon, the Philco

Left, the U.S. Navy's first operational guided weapon is the Convair Terrier seen here on the launching ramps on the U.S.S. " Canberra."

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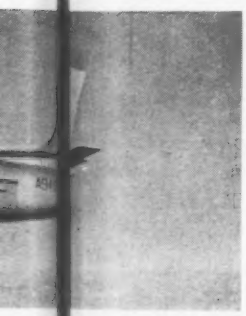
SIDEWINDER with infra-red homing and with the same speed is operational, and the same contractor is also developing another weapon called DIAMONDBACK. There is also an unguided rocket ZUNI for the Navy.

The only air-to-air weapon for the U.S. Air Force is the Hughes FALCON, although this has two forms, one with a semi-active homing system and one with infra-red homing. The alternative homing systems are to be fitted to a rear carcase which appears to be of the same shape and design for both.

Air-to-surface weapons are disclosed only by the United States, none by the Russians. The Navy shows a light weapon weighing only 540 lb. with command guidance. The Bell RASCAL, for the Air Force, is in production, its weight has not been given but its length is 30 ft., its diameter is 4 ft., and it has a range of 100 miles with inertial guidance and terminal homing.

Left, the Bell Rascal air-to-surface weapon and, above, a Canadair CF-100 Mk. 5B carrying four Sparrow 2 missiles.



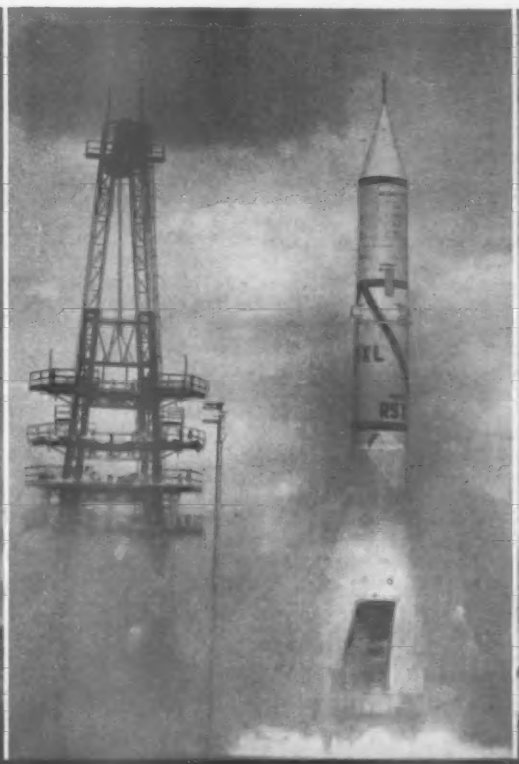
Left, much valuable development work on the D.H. Firestreak air-to-air weapon has been done at Woomera on Australian-built Sabres. Below, left to right, are a Boeing Bomarc being launched; a Redstone ballistic missile; and a Navaho test-fired with its booster which it rides "pick-a-back."

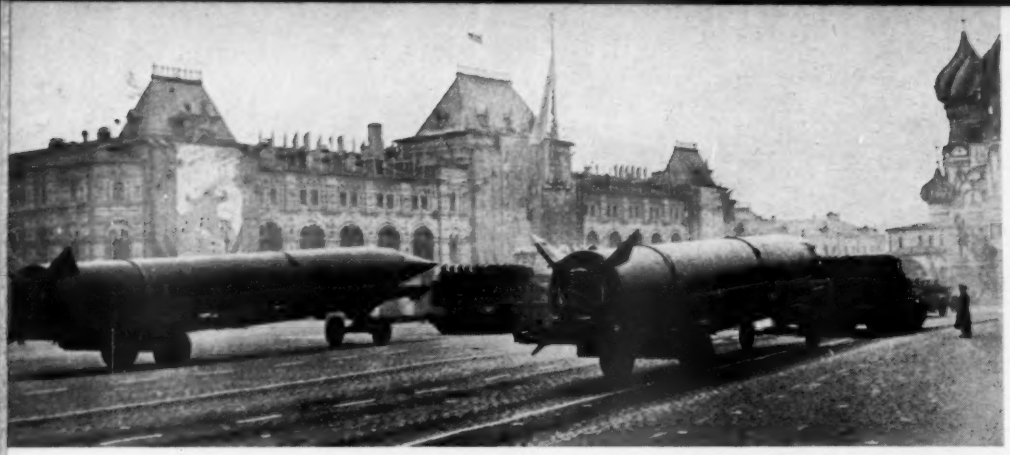
It is puzzling how terminal homing will work on a ground target for no information has been published on means of doing this. The U.S.A.F. also has three other air-to-surface weapons under development including HOUND DOG for use on the B-52, and there are two other weapons, Service unstated, of which one, CROSSBOW, has the valuable capacity to dislocate the enemy defence for it homes on enemy radar.

There are three United States' and no Russian air-to-surface weapons for the special purpose of submarine attack. PETREL is a naval torpedo fitted with an airframe, controls and a turbojet engine; it has active radar underwater homing. RAT also is based on a torpedo which has acoustic underwater homing. And a new family, ASROC, ASTOR, and SUBROC, about which no information has been disclosed, is under development.

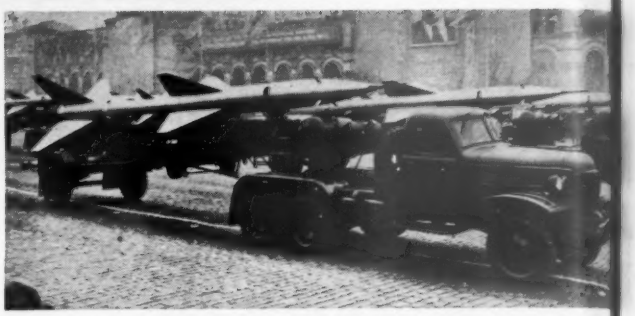
One Russian weapon only is listed in the field of surface-to-air weapons for defence, and no particulars are given except its size which is usual for this type of weapon and the method of guidance by command link. So long as the Western powers rely on bombers, this type of weapon is of great interest.

The United States was quick to recognize the value of guided weapons in defence, and the U.S. Army had developed and brought NIKE AJAX into service by 1953. Nike Ajax depends on command control—the weapon and the target being tracked by radar, and the command being given to bring the weapon to intercept the target, when the weapon is detonated, also by command. Extreme accuracy is needed in the system to give the position of the weapon and the target which are measured





Little information has been released about Russian guided weapons but these photographs of the Moscow parade last November show two types—a surface-to-air missile and a large ballistic rocket.



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at long range from the launching point, because the miss distance —which is found by the difference between the large dimensions of these vectors—must be small. NIKE HERCULES, an improved design, has a range increased from 20 to 40 miles and possibly may be fitted with a final homing stage to overcome the difficulty of maintaining accuracy at the increased range. Both systems depend on radar observations and on command signals so that they both might be affected by enemy jamming.

NIKE ZEUS is the latest improvement under development and is understood to have a much increased range.

The U.S. Army also has a weapon for low-level defence, the Raytheon HAWK which has semi-active homing and a range of 20 miles.

The Navy defensive weapon which is operational is TERRIER 1 —a beam rider of 1,000 lb. weight and a range of 12 miles. TERRIER 2 in production is also a beam rider and the range has been increased to 20 miles; a smaller version, TARTAR, has been produced for small ships.

An improved weapon, the Bendix TALOS, is in production for the U.S. Navy and is also under development by the U.S. Air Force and the Army. Developed with the help of experience from Terrier, ramjet propulsion has been adopted and the range has been much increased thereby to 43 miles. The increase of miss distance likely at the higher range with a beam rider has been avoided by adding a semi-active homing stage for the final phase of the interception. The development of the weapon by the three Services shows that it is good.

For the United States Air Force is the Boeing BOMARC which is in production and can carry an explosive or an atomic warhead. It has a range of 250 miles and is driven by two ramjets after a vertical launch by one liquid rocket. Command guidance is used in the initial part of the interception, with fully active homing for the final stage. It can best be operated by means of SAGE, the automatic electronic radar defence system designed to cover the U.S.A., which can feed the data necessary to control Bomarc through a computer to the command link. The operational height of this weapon is said to be 60,000 ft. so that it is adequate for all known aircraft.

WIZARD is a system for intercepting ballistic weapons which is being worked out by Convair and the Radio Corporation of America. It depends on timely radar observation of the enemy weapon and the necessary radar performance to give 15 minutes' warning of an approaching weapon has been achieved. The object is for the defending missile to intercept the attacking ballistic weapon outside the atmosphere and there explode a nuclear warhead.

Surface-to-surface weapons of both countries fall into two classes, namely the flying-bomb-type, which is not being developed in the U.K. at all, and the ballistic weapon.

Russia has at least two flying-bombs, having ranges of about 500 miles and speeds of M = 0.8 and M = 1.3 respectively. Against these two the United States had seven projects, of which two, NAVAHO and TRITON, have been cancelled.

The problem of the flying-bomb can be stated in one word, navigation. Otherwise it is a kind of aeroplane with the ordinary problems of an advanced type, and automatic control achieved with the normal development of established systems.

Guidance of the U.S. MATADOR, which is, in effect, a small turbojet-driven aeroplane with a range of 600 miles is given as "command" which sheds little light on the method of navigation as it does not disclose the method of determining the position. The position of the bomb could be followed from the command post by radar tracking, and the bomb could carry a transponder to multiply the strength of the echo and this could be supported by a dead-reckoning system to follow the position through periods of jamming or for a short distance at extreme range.

Matador which is operational, is followed by MACE which is in production, also from Martin, having a similar range and also driven by a turbojet. It is said to have the more advanced inertial guidance and so is free of the effects of enemy countermeasures which could jam a command and radar observation system. Both these weapons are for the U.S. Air Force.

For the U.S. Navy is the REGULUS, of which Regulus 1 is in operation, and Regulus 2 is in production. These are both large weapons, of 12,000 lb. and 26,000 lb. weight respectively and with ranges of 500 and 800 miles. Again the guidance of these two is given as "command."

The Air Force also has the long-range weapon SNARK by Northrop, which was seen at the Paris Show in 1957. This is a fine big aeroplane with swept wings and turbojet engine of 11,000 lb. thrust and with rocket-boosted take-off from a launcher. The range is 5,000 miles at M = 0.9. The guidance is advanced, by stellar and also inertial navigation. This tremendous weapon is operational, while the ballistic weapons are still being developed and are not ready for use, except for the short-range Redstone and, possibly, Corporal.

Russian Ballistic Weapons

The biggest Russian effort in any field of guided weapons is in the ballistic type. Of five types about which information is available, one is an unguided tactical rocket of 16 miles range; it corresponds to two U.S. types of this kind having 15 and 10 miles range respectively.

The method of guidance of the other four Russian weapons is not known; though inertial guidance systems are probably used; a radar system is an alternative possibility. The types fall into a consistent family of increasing size and, where stated, increasing range. The T7a which is 35 ft. long has a range of 30 miles, the T1 is about 50 ft. long; the T2 is 67 ft. long and has a range of 400 miles and a weight of 50,000 lb.; and finally there is the T3 about 80 ft. long and with a range of 5,000 miles.

Achievement of the Sputniks has shown that all these weapons, including the largest, are comfortably within the ability of the Russians to produce. The degree of accuracy of the Russian guidance system cannot yet be clearly judged. While the success of the Sputnik system shows that the problems of structural engineering and propulsion have been overcome, the

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guidance is yet another problem and there is a little indication that it may not have been solved to the degree of accuracy that is desirable.

A comparison was made recently of the degree of accuracy needed to put a satellite into its orbit, and to put a warhead on its target. It was there shown that the guidance instruments which were accurate enough to give a miss distance of two miles in an intermediate range ballistic weapon could, if used in a satellite system, put the satellite into an orbit at a height of, say, 200 miles, which was circular but for two miles increase in height at apogee above the true circle, and two miles decrease in height, below the true circle, at perigee. If the Russians had been trying to put Sputnik into a circular orbit, the accuracy they achieved was very much below this level.

America's Ballistic Variety

The United States' effort on ballistic weapons appears to correspond to the Russian effort in size and as stated certainly exceeds it in variety; in addition to the two short-range unguided ballistic weapons mentioned with the corresponding Russian weapons, the U.S. Army has five full ballistic weapons. The U.S. Air Force has four, and the U.S. Navy has one weapon designed to be launched from a submarine when submerged.

The original U.S. Army weapon, CORPORAL by Firestone which also is being supplied to the U.K. is for tactical use and has a range of 100 miles. It can be fitted with an atomic warhead. A replacement, SERGEANT, of smaller size is being developed by Sperry with a range of only 75 miles. Corporal guidance is by command, believed to be a radar-doppler system, and Sergeant is to have inertial guidance.

REDSTONE is the medium-range weapon for the U.S. Army, developed by the team at Redstone Arsenal. This is understood to be the largest weapon yet in service and is a development of the V.2 having been designed by the team under Wernher von Braun who became a naturalized U.S. citizen after the War, going there from Peenemunde, where he had worked on the V.2, to continue the development of ballistic weapons. Redstone uses external control surfaces like the V.2, with small moving surfaces in the rocket blast for initial control at the low speed immediately after the launch. To replace Redstone, PERSHING is being developed for the Army, with a 500-mile range.

It was a modified and improved Redstone named JUPITER "C" which put the U.S. satellite into its orbit. Jupiter, a different and larger Army weapon is also being developed by von Braun, and has had the good practical reliability which seems to be typical of his work. It is 60 ft. long, weighs 105,000 lb. and has a range of 1,500 miles. Unlike Redstone, it is controlled by pivoting the combustion chamber of the rocket.

Guidance for Jupiter is by the inertial system, with an alternative radio-inertial system which could be installed instead. It is this weapon which has come under the ruling by the Secretary of Defence that land-based weapons with a range greater than 200 miles should be the responsibility of the Air Force so that its future, in spite of successful tests, is uncertain.

THOR is the Air Force weapon which was ordered on a "crash" programme after the ruling had been made by the Secretary of Defence, to compete with Jupiter. The first weapon was fired at Patrick in the remarkable time of 12 months from the start of the programme, but the results of this launch and of the next two attempts made the description of the programme above into a nice joke. More successful firings have followed, and this is the weapon that is to be supplied to the U.K. as the result of the Prime Minister's visit to Bermuda in 1957.

In spite of its rapid development, the Douglas company which is the prime contractor for Thor has gone to an advanced design. The nose cone is similar to the nose cone for Atlas, and the guidance has largely been taken from Atlas and from Titan (which are described below). Besides the inertial guidance system being developed, there is an alternative radio-inertial system with Bell telephone ground radar.

Weight is of extreme importance in a long-range ballistic weapon and, to achieve the lightness required, a remarkable structure has been used for Atlas in which the skin is thick enough only to take tension loads and is prevented from buckling under compression by maintaining fuel pressure or gas pressure constantly inside it. The structure of Thor also uses this type of pressurized body and the pressure also assists in giving a good fuel feed. The single rocket engine has a rated thrust of 165,000 lb. and is mounted on gymbals so that it can be deflected to give directional control. The engine runs on kerosine and liquid oxygen.

POLARIS, the Navy weapon under development, is to have a range of 1,500 miles like Thor and Jupiter. The problems of launching from a submarine when submerged affect the design from the beginning. The propulsion is to be by solid rocket and the engine, which is the biggest solid-fuel rocket ever built in the United States, has been fired.

The system to be used for guidance is inertial, and it is understood that responsibility for the whole system including the navigation of the ship is allotted to the Massachusetts Institute of Technology. The inertial system of navigation of a weapon works with reference to the position of its initiation, normally the firing point, and so the navigation of the submarine is as important as the navigation of the weapon.

As a nuclear submarine can remain submerged for long periods and can travel at high speeds when submerged, this may be equally difficult. A ship's system believed to be inertial has been developed and is claimed to give a satisfactory degree of accuracy. If inertial, it has the advantage that it works when submerged and needs no connections to outside stations. Besides navigation, there are many problems of storing the weapon under water, erecting it, firing the engine and making control connections.

The Long-range Weapons

The two intercontinental ballistic weapons under development for the U.S. Air Force are ATLAS and TITAN. Each is to carry an atomic fusion warhead and to have a range of 5,500 miles. To achieve so great a range, a high proportion of the take-off weight must be given to fuel, and light structure weight is essential. For this the pressurized structure of Atlas was originated, which is also used for Titan and Thor. The body skin is itself the tank for the fuel and oxygen, and both fuel and oxygen spaces are pressurized.

Atlas is launched with a central sustainer engine of 65,000 lb. thrust and two boost engines of 135,000 lb. all working together. The two boost engines burn for 180 seconds and then are jettisoned together. All three engines are pivoted so that they can be deflected to give directional control. The speed of the weapon is of the order of M = 20 so that the nose is intensely heated when it re-enters the atmosphere; the contract to develop the nose to resist this heating was given to General Electric at a cost of over £50 million.

The hydrogen fusion warhead is understood to weigh some 3,000 lb. The guidance system being developed by General Electric is radar-inertial in contrast to the guidance system for Titan which is being developed as pure inertial. The U.S. Air Force has the information on the progress of these two systems which may be interchangeable up to a late stage in development. Atlas was intended to come into service next year.

Martin, the prime contractor for Titan, have designed a tandem two-stage weapon in which the engine of the second and final stage is covered by the first stage and is fired when the first stage has separated. The Aerojet engine in the first stage is mounted in gymbals so that it can be swivelled and is the sole means of directional control as with Atlas; its thrust is 300,000 lb. The final-stage engine is also in gymbals and gives a thrust of 60,000 lb.

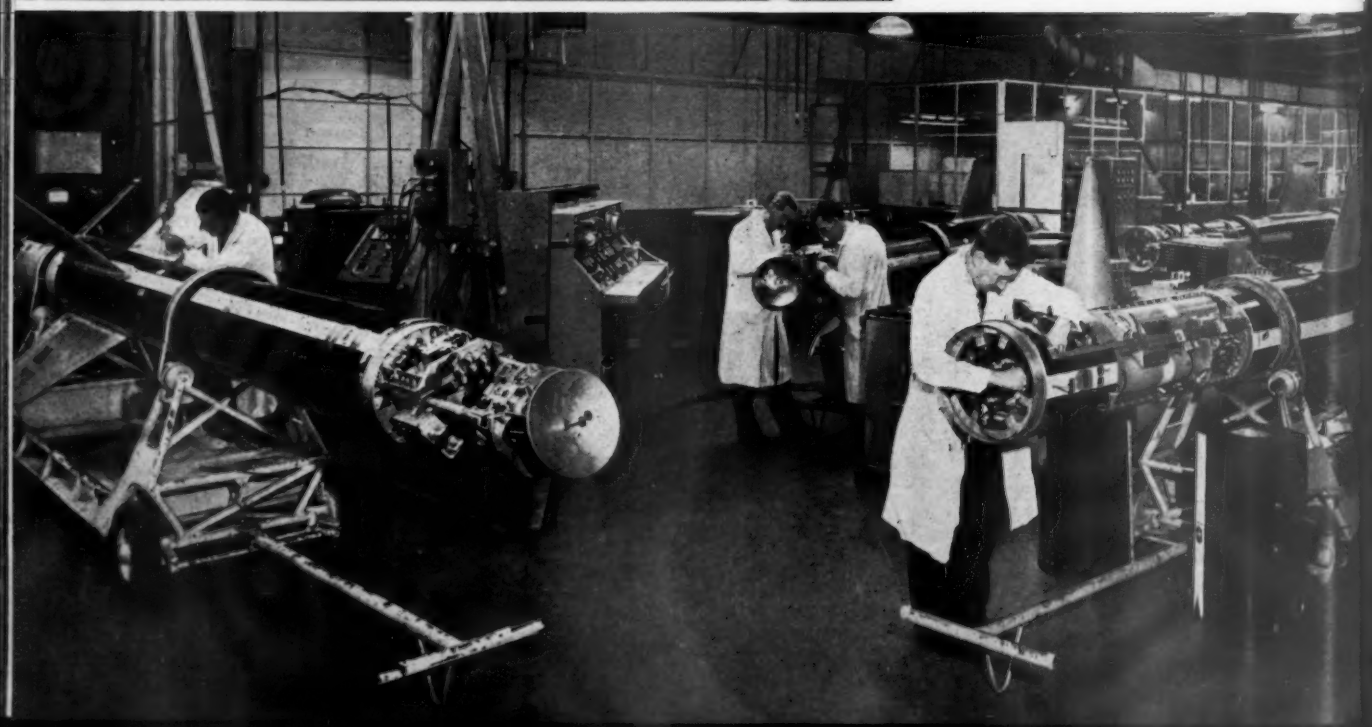
An inertial guidance system is being developed for Titan by Arma Bosch, and an alternative radar-inertial system is being developed by Westinghouse and Bell Telephone. The contract for the nose cone has been given to Avco who have a shock tube in which the great velocities of re-entry and their accompanying temperatures can be reproduced for trials of the heat-resisting capacity of model heads.

The reliability of these weapons is likely to prove to be important, and a close watch will be kept to see what proportion of them misbehave after firing. It will also be interesting to see if the statements that it is impossible for atomic warheads, whether fission or fusion, to go off during an accidental crash are well founded.

Missiles and Astronautics . . . .

An Essential Research Task

A noteworthy co-operative effort in research associated with guided weapons development is the programme undertaken by Elliott Brothers (London) Ltd., and Short Brothers and Harland for the Ministry of Supply. In this, all manner of guidance and control problems are investigated using Elliott electronic equipment and the Short G.P.V. test vehicle. Rounds from Belfast are delivered to Elliott's Trials Section at Rochester where the guidance equipment is installed prior to dispatch of the round to Aberporth for firing. On this page the test vehicles are seen being "readied" at Rochester.



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Guidance and Control of Guided Weapons

by D. Howe, D.C.Ae., A.M.I.Mech.E., A.F.R.Ae.S.

ESSENTIALLY, a guided weapon is one which seeks to reproduce at comparatively great range the accuracy which can normally be obtained only at close quarters. As such it differs considerably in its make-up both from conventional ammunition on the one hand and manned aircraft on the other, possessing as it does some of the characteristics of both and others of its own which are unique.

Those whose main concern is aircraft often tend to regard guided missiles as rather uninteresting, cheap and nasty poor relatives of the higher breed. This is to do them a considerable injustice and to some it comes as an unpleasant shock to realize that supersonic aircraft are tending to become similar to missiles, particularly from the point of view of control and stability.

The most obvious difference between a guided missile and a normal aircraft is that, with the exception of certain Japanese suicide bombers, the human pilot is replaced by a guidance system. Many of the restrictions imposed by a pilot, both in layout and operation, are thus removed although the guidance itself will impose certain other limitations. It is possible, and usually highly desirable, to design a missile to utilize much greater accelerations than would be the case for a manned aircraft. In addition, the safety aspect is much less important, except where a failure would endanger other equipment or personnel.

Another difference is that the missile is designed for a single flight and, moreover, is not required to return to its base. This has two important effects. On the one hand, since the missile is expendable it is necessary that cost be kept to a minimum and this is helped to some extent by the easier design conditions of short-life operation. On the other hand, the absence of a landing requirement enables the missile to be designed for one range of speeds, usually supersonic, with the consequent opportunity to obtain a more suitable aerodynamic configuration.

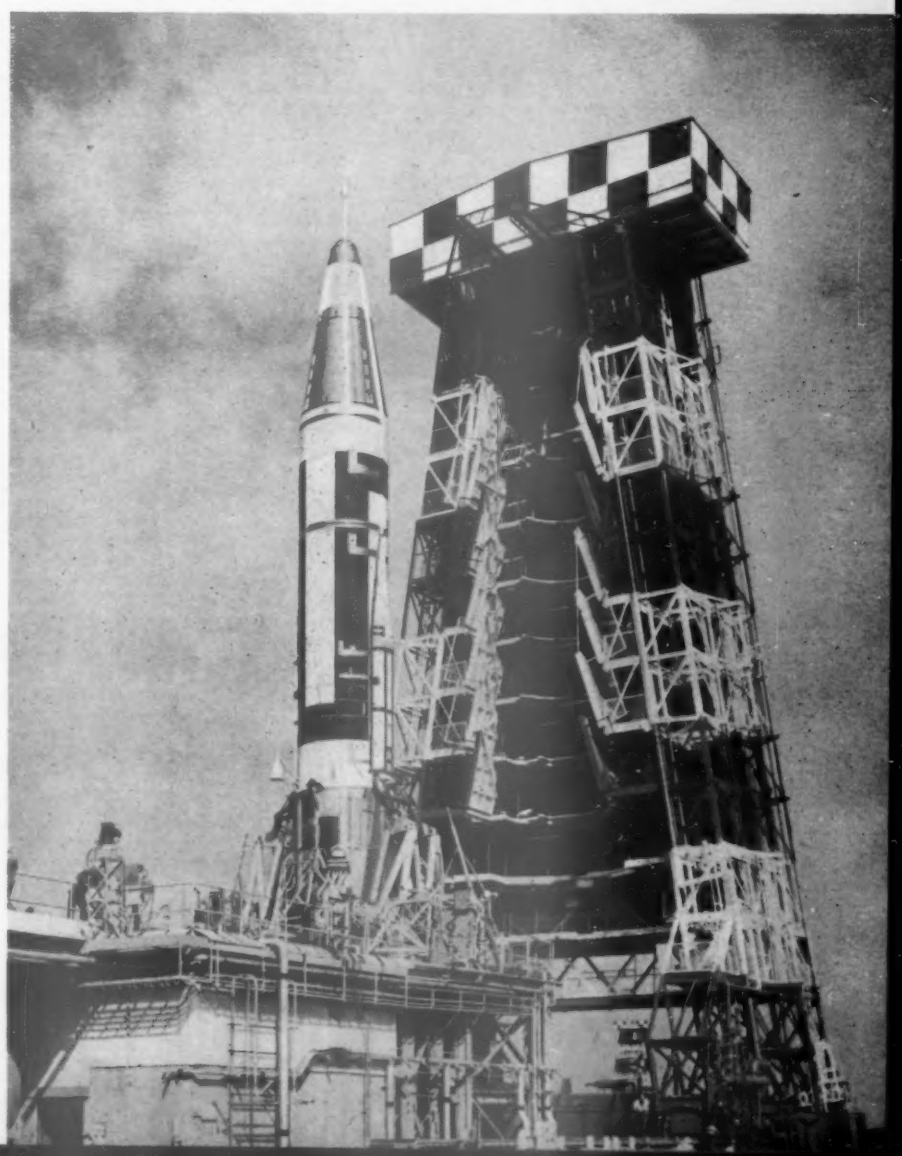
As the missile is a much smaller unit in the weapon system than is the case with a manned aircraft, the requirements of the other units of the system may well dictate the design of the missile itself rather than the other way round. Of course this is sometimes true of an aircraft—a good example being the limitations imposed upon a naval machine by the need to be able to operate it from a carrier—but usually such restrictions are more numerous and important in a missile design.

The final, and probably the most important, difference is the reliability aspect. At first sight this may not appear to be obvious, but should a small failure, of say, any item of electrical equipment, take place in an aircraft it is usually simple for the pilot to take remedial action without appreciable detriment to performance. Thus although reliability in a manned aircraft is important, a considerable degree of unreliability can be, and is, put up with. Not only must a missile operate under more severe conditions, but also failure of any one small component will almost certainly result in an aborted mission.

The guided missile itself can be divided into six major components: (1) The guidance and navigation system, which in some instances may, in fact, be partially outside the missile. (2) The control system. (3) The propulsion units, inclusive of boosts if used. (4) The power supply and control actuation system. (5) The armament. (6) The airframe.

Here, however, we are concerned only with the first two of these important components—the guidance and navigation, and control systems.

First, let us consider guidance and navigation. This is



A U.S.A.F. Atlas intercontinental ballistic missile on its launching pad at the test establishment at Cape Canaveral. The dominant gantry which is used for pre-launch preparation of the missile is being moved back from the pad in readiness for the launching.

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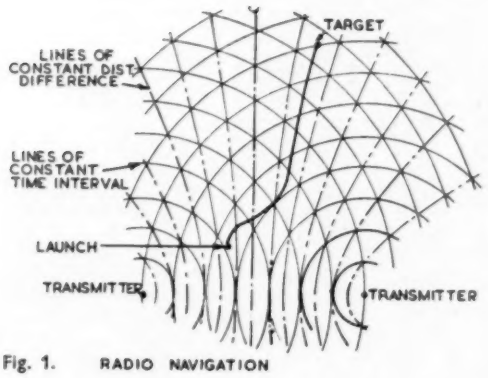

Fig. 1. RADIO NAVIGATION

inevitably linked with the whole weapon system and in some cases the missile carries only a small portion of the equipment needed to give satisfactory guidance. The type of guidance used is very dependent upon the type of target the missile is required to attack.

From the point of view of the guidance system the targets fall into two broad categories: (a) Static targets; (b) manœuvring targets. Air targets are invariably manœuvring as also are certain surface targets, like ships and tanks. The manœuvring capabilities of these surface targets are not likely to be as great as those of aerial targets, however.

In the case of a static target the position of the target relative to the missile, or to some known origin to which the missile can be related, is all the information outside the missile which the guidance system requires to know. However, when the target is moving its motion and possibly also its position relative to the missile must be known. In general the guidance system for use against a moving target must continually sight the target.

The guidance system establishes the motion of the missile relative to its target whilst the navigation system computes the missile motion necessary to intercept the target. This information is then passed to the control system which causes the missile to behave as required.

STATIC-TARGET GUIDANCE SYSTEMS

These systems are normally based on the use of information imparted to the missile prior to launch. This information is often in the form of a flight programme.

Magnetic Heading

One of the simplest types of guidance system is that using a predetermined magnetic heading. An auto-pilot placed in the missile receives information from a magnetic sensing element and constrains the missile to fly on a given course. Since the missile flies in a sensibly straight line, the problem of interception is simple. An improvement can be made in this direction by incorporating one or more preset and pretimed turns in the flight plan. After a preset time has elapsed, the missile dives onto its target.

Later versions of the FZG 76 flying bomb used this form of guidance.

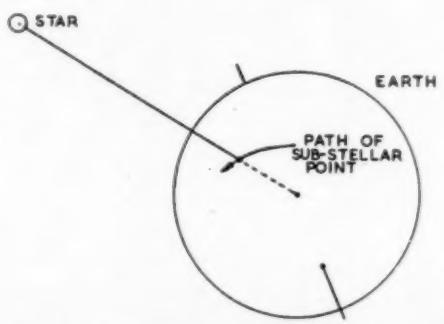

Fig. 2. SUB-STELLAR POINT

Command Set Ballistic Trajectory

The missile is controlled during the initial part of an otherwise ballistic path. Thus the guidance is used only to correct launching errors and set the correct trajectory, and has been described as a long flexible gun barrel. The accuracy will decrease considerably over longer ranges.

Radio command or wire tension can be used to impart the guidance signals; the French Veronique rocket uses the latter method.

Radio Navigation

Such a system is basically that used for the aerial navigation of conventional aircraft, as for example, LORAN, and Gee.

Pulses of predetermined time spacing are transmitted from two ground stations which are a known distance apart. These pulses are received by the missile which measures the difference in time of reception of the pulses from the two transmitters. This immediately yields the difference in distance from the transmitters, a line of constant distance difference being a hyperbola, as shown in Fig. 1.

The missile navigational system uses this information in conjunction with the time from launch to compare the missile's position with a predetermined flight path. An error signal is thus obtained which is fed to the control system to cause the missile to keep to the required trajectory.

This system requires only simple equipment both in the missile and on the ground, and is capable of dealing with a number of missiles at any time. Unless elaborate precautions are taken it is not difficult for the enemy to interfere with the system. The final dive onto the target is arranged by means similar to those used for magnetic heading guidance.

Inertial Navigation

Inertial navigation is a very simple concept. The accelerations or motions of the missile in all three planes are measured throughout its flight. A flight path is computed from the information obtained and this is compared with a programmed trajectory in order to obtain an error signal for control.

In practice inertial guidance is rather more complex than this would suggest, unless only very short range is required. Missile accelerations which cause a deviation from the desired flight path are usually very small and yet have a great effect upon deviation distance at long range. Hence extreme accuracy is essential to obtain satisfactory guidance.

If accelerometers are used to measure the missile motion, these must be mounted on a gyro-stabilized platform. Unless the stabilization is very accurate the platform will not provide the correct reference for interpreting the accelerometer measurements. Alternatively, gyros can be used to establish the missile motion and the extreme accuracy required implies that they must be large and consequently heavy.

The programmed flight path must be related to known reference points. The most obvious one of these is the launching site, but it is desirable to have references which enable corrections to be made more accurately during the later stages of the flight.

One such reference is the direction of the specific force of gravity which is unique for any given point on the earth's surface. If the missile guidance system incorporates a sensing device it can compare the direction of the gravity force at a given point in the flight with that at the target. When an inertial system uses gravitational or magnetic references it is termed an inertial terrestial system. Another approach is to use the positions of heavenly bodies as a reference, in what is known as an inertial-celestial system (see below).

One of the most important advantages of inertial guidance is its independence of information from outside the missile other than geophysical properties. No ground facilities are required and it is virtually immune to enemy countermeasures. In addition it transmits no signal and thus does not betray its presence.

This type of guidance is especially suited to long-range missiles, such as Thor, Jupiter and Atlas.

Celestial Navigation or Star Tracking

There are various ways of using stars for guidance purposes. One obvious one is to provide the missile with instruments and computers to enable it to perform standard astro-navigation, comparing its position with a programmed flight path.

Another method is to make use of the track of the "sub-stellar" point of a particular star. The sub-stellar point is the location on the earth's surface where a line joining the star to the centre of the earth intersects it, as is indicated in Fig. 2. As the earth rotates, this point traces a line across the earth's surface. The missile can be equipped with a device to follow

(*Continued on page* 587)

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(*Continued from page 586*)

the movement of the sub-stellar point and use it as a reference for its flight.

The most suitable star would be one whose sub-stellar point passes close to the target at the required time. If inertial guidance is combined with the tracking of the sub-stellar point then the missile flight path can be independent of the movement of the point, otherwise considerable limitation to the flight plan may be imposed.

Celestial navigation is virtually immune to interference by the enemy, but relies upon the ability of the missile to see the requisite stars. In some respects its use to assist inertial navigation can be regarded as an interim measure pending the development of pure inertial systems of the desired accuracy. The Snark uses a star-tracking guidance system.

MOVING-TARGET GUIDANCE SYSTEMS

When the target is moving it is essential that the guidance incorporates a means for the missile, or some unit in the system, to watch the target continually.

Command Systems

In a simple command system the missile is controlled by an operator who is located in a position suitable for sighting the target. This position need not necessarily be at the launching point. The system is shown in Fig. 3, the operator observing both the target and missile and controlling the missile as

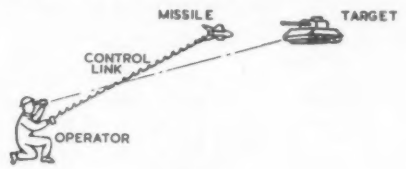


Fig. 3. COMMAND GUIDANCE

necessary. Flares are often placed on the missile to assist the visual tracking, and refinements include the use of optical devices such as binoculars.

There are two common methods of linking the operator with the missile. In the first of these, the missile trails behind it a wire, or wires, through which electrical control signals are passed. Normally the wires unwind from spools on the missile and there is a range limitation arising from the length of wire carried. The system is simple and practically immune to interference, and for these reasons is especially suitable for small missiles of the anti-tank type such as the Vickers 891 and French SS 11.

For the second method, the use of a radio link increases the range potentiality to the limit set by the operator's vision. Although it is basically a simple system, it is prone to interference by the enemy unless special precautions are taken—this implies complication. The application of this system is limited to small missiles which require a range rather greater than can be achieved by the use of a wire link. Early surface-to-air missiles such as the German Hs 117 had radio command guidance systems.

Command System with Remote Tracking

It is possible to overcome the range limitation of a simple command system by equipping the missile with some device, for instance a television camera, to enable it to watch the target. The picture of the target is relayed to the operator who uses his radio link to give control signals to the missile.

In some respects this system is not unlike a homing guidance (see later) as accuracy should increase as the target is approached. The main disadvantage is the relative ease with

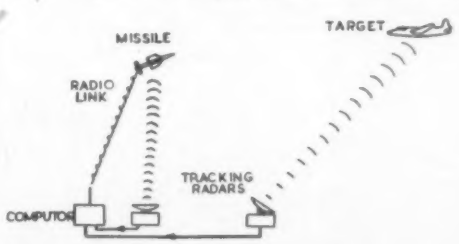
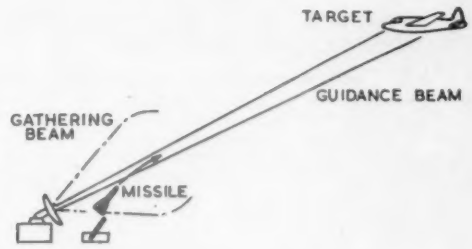


Fig. 4. COMMAND LINK GUIDANCE



BEAM RIDING GUIDANCE Fig. 5.

which the picture can be interfered with, unless complex radar devices are used.

Command Link System

A command link system is an elaborate development of the simple command system and aims at removing its limitations. The target is tracked by ground-based radar which computes its velocity and position. A similar installation tracks the missile. The information from the two tracking sets is fed into a computing unit which evaluates the required course for the missile to achieve interception and transmits the appropriate control signal by radio link. The layout is indicated in Fig. 4.

The guidance unit in the missile is simple, even when more elaborate tracking aids are necessary to reduce the effect of enemy countermeasures. However, the ground equipment is complicated and bulky and can only handle one missile at a time. The complicated ground installations imply that such a system is best suited for fixed defence installations such as are used with Nike Ajax.

Beam Riding

A logical development of gunnery techniques, the beam-riding guidance system operates by causing the missile to fly along a beam directed at the target as shown in Fig. 5. The beam may be of light—the missile using photo-electric cells to keep it in the beam—or, more usually, radio. Either a surface or airborne installation can be used to direct the beam.

There is a range limitation on accuracy as the beam width increases in direct proportion to the distance from the source, and in order to obtain the highest accuracy a small-angle beam is necessary. Because of this it is often not possible to launch the missile directly into the main guiding beam and so a wide-angle gathering beam is used initially.

The missile guidance components are relatively simple and a number of missiles can be launched into one beam, but each target requires a separate beam. As the beam must always point at the target it can be locked on and act as its own tracking radar. A ground installation is simple and can readily be designed as a mobile unit.

As the beam is definitely directional it is difficult for an enemy to use countermeasures. The need to follow the target with the beam imposes a limitation upon the manœuvres of the parent aircraft in an airborne installation, and the flight path of the missile in a ground installation. Examples of beam-riding weapons are the Fireflash, Oerlikon 54 and Terrier.

Homing Guidance

In a homing guidance system the missile itself is provided with a device for looking at the target. Because of this the accuracy of the system will tend to increase as the target is approached, although there are certain factors, particularly noise, which may offset this effect. It is not necessary for the missile to know its distance from the target, the important parameter being the rate of turn, or "spin" of its sight line to the target.

The three variations of homing guidance are shown in Fig. 6.

(a) ACTIVE HOMING. For this, the missile is equipped to transmit radio signals in the direction of the target. The reflected signals enable the homing head to lock onto the target and enable the navigational system to compute the required control signals.

Once fired the missile is independent but it must carry its own complex and relatively heavy guidance pack. The size of the radar aerial, or dish, is usually determined by the range required, and the limited space available in a missile implies a very considerable range restriction.

The radar used could be either a pulse system which estimates

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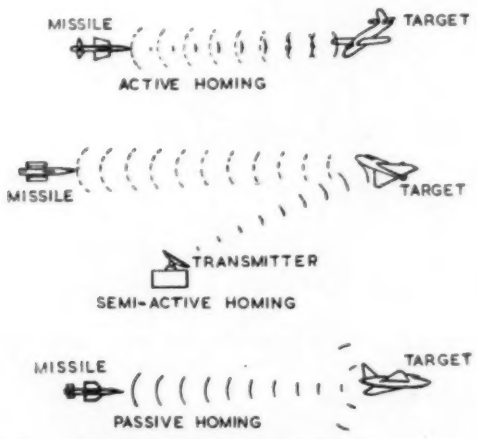

Fig. 6 HOMING GUIDANCE SYSTEMS

target range and position, or continuous wave which relies upon Doppler effects and thus estimates target velocity. This latter has some advantages but, unless an exceedingly complex unit is tolerated, the transmitter and receiver units must be separated by a considerable distance, or the installation is impracticable.

(b) SEMI-ACTIVE HOMING. With this system the target is illuminated by a transmitter which is located outside the missile, but the missile receives the reflected signals and uses them as in the case of fully active homing. The guidance set in the missile is less complex and, since the transmitter can be larger and more powerful, the range restriction is removed, to some extent at least. The transmitter is separate from the receiver so continuous-wave radar can be used without undue difficulty and each transmitter can serve a number of missiles. As it must be locked onto the target, however, an airborne installation will restrict the performance of the launching aircraft. Both the Thunderbird and Bloodhound employ semi-active homing guidance.

(c) PASSIVE HOMING. Many targets emit signals which can be used by a missile homing set. No special transmitter is thus necessary and once fired the missile is independent except for the target. The most usual forms of signals emitted by a target are sound, heat and light, although the last-named is usually reflected. The absence of the need for a transmitter results in a simple, flexible system and enemy countermeasures are limited to the provision of an alternative source of energy.

The most usual passive homing systems in airborne missiles use infra-red heat-seeking cells—as for instance in Firestreak and Sidewinder. The Matra MO51 uses a light system and homing torpedoes use acoustic devices. Infra-red systems are suitable for day or night operation but the presence of cloud at lower altitude may restrict their use to greater heights.

MIXED GUIDANCE SYSTEMS

It is often desirable, especially in the case of long-range missiles attacking moving targets, to have a guidance system that is composed of more than one distinct type. When only one guidance system is used, this is often referred to as "All the way" guidance. If a mixed system is used there are usually three separate phases.

The first stage of guidance is always the launcher which is aimed in the approximate direction of the target when this is possible.

The second stage is referred to as the mid-course phase. The type of guidance used will depend upon the range and flight path desired. For instance, beam-riding, radio command or some form of programmed flight could be used. The purpose of this stage is to control the missile within reasonable limits so that the final guidance can be brought into operating range of the target.

End-stage guidance is usually of the homing type, when it is referred to as "Terminal" homing. The main problem involved in using this type of guidance system is associated with the need of the end-stage guidance to acquire the target.

Bomarc is reported to use command mid-course guidance with active terminal homing, whilst Talos is a beam rider with terminal homing.

MISSILE TRAJECTORIES AND MOVING TARGETS

The type of course flown by the missile will depend to a very great extent upon the kind of guidance used. For a "line of sight" course, the missile is controlled in such a way that it flies along the line of sight joining the control point to the target. A beam-rider system will give this trajectory. The manœuvre required of the missile will depend upon the location of the transmitter relative to the target, but can be large.

When the missile velocity vector is always directed towards the target, a pure pursuit course is flown. A command system could use this type of course, but an alternative approach is to arrange for the missile control system to cause the velocity vector to be at a constant angle to the missile's sight line to the target. This is known as a deviated pursuit course and can be used to enable the missile to anticipate target motion to some extent. A homing missile carrying out a tail attack on a target might be arranged to follow some form of pursuit course.

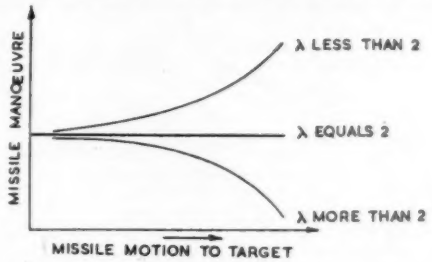

Fig. 8 CRITICAL PROPORTIONAL NAVIGATION CONSTANT (FIXED TARGET AND CONSTANT SPEED MISSILE)

A constant-bearing course is one where the sight line from the missile to the target remains constant in direction, as shown in Fig. 7. When both missile and target velocities are constant, a "collision" course results.

Because, in practice, most missiles and targets do not fly at constant velocity, and the target may manœuvre, a refinement known as proportional navigation is used. In this case the rate of turn of the missile flight path is arranged to be directly proportional to the rate of turn of its sight line to the target. This is expressed mathematically by $\Omega=\lambda\omega$, although the form of the equation is modified somewhat when there is noise present. Ω and ω are the rates of turn of the missile flight path and sight line respectively, and λ is known as the proportional navigation constant.

The value of λ is chosen so that the manœuvre required of the missile is not extreme. There is a critical value for λ, below which the missile manœuvre demand increases as the

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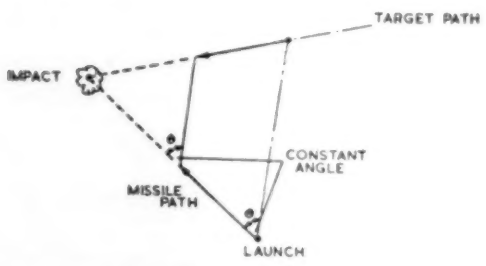

Fig. 7 CONSTANT BEARING COURSE

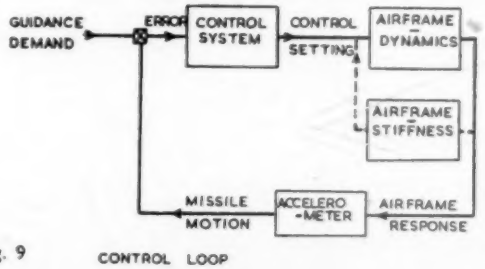

Fig. 9 CONTROL LOOP

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(*Continued from page* 588)

target is approached, whilst above it the opposite holds. For a fixed target and a constant-speed missile, the critical value is $\lambda=2.0$ as is illustrated by Fig. 8. The effect of target motion is normally to increase the critical value. In a practical application it is desirable to have a fairly high value of λ but the effect of noise restricts it.

Many homing systems use proportional navigation.

THE CONTROL SYSTEM

In general the missile control system consists of three basic components, although in some applications this division may not be immediately apparent.

First there is the auto-pilot, the purpose of which is to stabilize the airframe on a given course until it is overridden by guidance demands. Essentially it consists of devices such as gyros and accelerometers, for measuring missile motion away from the required path and providing a correcting control demand. It may be part of the guidance unit.

The second group of basic components are the control actuators. These convert the control signals received from the auto-pilot into a motive force to operate the controlling device.

Finally there are the controls themselves. The actuator motion is used to operate the control device to manœuvre the airframe as required.

A typical control system can be represented by a block diagram of the form shown in Fig. 9. An input signal is received from the guidance and navigation system which causes the control actuators to initiate an airframe manœuvre. The degree of manœuvre is recorded by an accelerometer or other similar instrument which feeds a signal back to the input line. This signal when compared with the input signal results in an error signal which has the effect of adjusting the control actuators, and so on, until equilibrium is achieved. The effect of structural flexibility in the airframe is to cause an additional feed back in parallel to that recorded by the accelerometer, and this may present serious difficulties in certain circumstances.

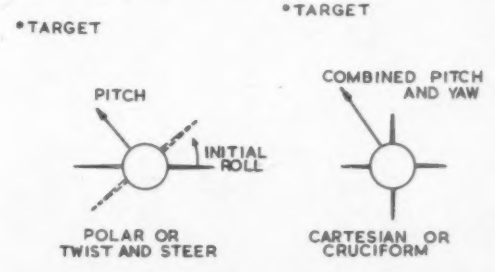
Control System Requirements

The control system must provide sufficient force to enable the missile to manœuvre in accordance with reasonable guidance demands, and it must be able to do this in a time which is sufficiently short to keep these demands to a reasonable level. As has been indicated by the block diagram of the control loop, the aerodynamics of the missile, and to some extent its structure, are intrinsically part of the control system.

Missile manœuvrability is expressed in terms of the acceleration imposed upon it, relative to that of gravity. The value of g which a missile is required to pull depends upon its target and flight path, and an anti-aircraft missile may have to be capable of a manœuvre of the order of 12 or more g. This manœuvre is in a plane normal to the direction of flight and thus it is a function of the lift obtainable from the body-wing combination. Since the lift obtainable will decrease with height and large wings impose a drag and weight penalty, it is often necessary as a result for the missile to fly at large angles of incidence.

The rate at which the control system can cause the aircraft to pull the required g is a function of the aerodynamic and structural design and the response of the control system. In most instances the control system response time is very much less than that of the airframe.

The movement of the control may be arranged to be continuous over the whole angular range, the actual displacement being decided upon by the guidance demand. Alternatively a simple three-position system may be adequate. Such a control is known as a "bang-bang" type, i.e. it is either central or at one extreme according to the demand. A "bang-bang" system is obviously less accurate but is much more simple and reliable.



WING ARRANGEMENTS Fig. 10.

Airframe Configurations

There are two basic configurations which can be used to obtain missile manœuvre, and these are indicated in Fig. 10.

(a) POLAR, OR TWIST AND STEER. The missile is provided with one pair of wings only in a manner similar to a conventional aircraft. In order to turn towards a target the missile performs two distinct manœuvres. First it rolls into the plane of the target and secondly it pitches in the required direction. In practice these two operations may to some extent coincide, but there is inevitably a time penalty due to the necessity to perform both manœuvres. Against this there is only one pair of wings to cause drag. The roll control will be in accordance with demand, and the missile has to be stabilized in yaw.

(b) CARTESIAN. In this case the missile is provided with at least three wings to enable it to pitch or yaw in any direction, without the need to roll. In practice the tri-form arrangement is limited to fins which are not used for control purposes and normally two pairs of wings, known as a cruciform arrangement, are used. Only one stage in the manœuvre is necessary so that there is better response than is the case with the polar arrangement, but wing drag is greater.

Although it is not necessary for a cruciform missile to execute roll manœuvres, in attacking its target there is always a tendency to roll in a practical case. This arises partly from inevitable manufacturing inaccuracies which cause asymmetric loads and partly from an induced rolling moment which occurs when the missile pulls g in a combined pitch and yaw direction.

With some guidance systems, for example beam riding, it is necessary to know the location of the wings in a roll sense to enable the correct control to be obtained and in these instances what is known as "roll stabilization" is incorporated in the missile. A gyro is used to provide roll error signals which enable the controls to apply rolling moments of sufficient magnitude to keep the wings in a predetermined roll location.

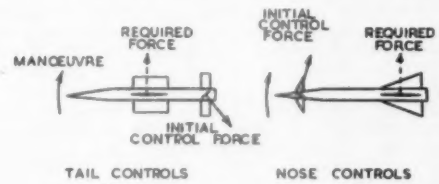


Fig. 11.

With some homing guidance systems this is not necessary since the missile can interpret the guidance demands relative to its own axis, but practical design considerations limit the rate at which the homing head can rotate about its fore-and-aft axis. If the missile rate of roll is greater than the homing head limiting value, the guidance system will lose lock of its target and in these circumstances "roll rate stabilization" is used. Here error signals relate to the rate of roll and this is restricted to a sufficiently low value by appropriate control movement. In some special instances rolling capacity is deliberately built into a missile to provide some degree of directional stability.

Due to symmetry the mechanics of the cruciform missile are simpler and more completely understood than those of the twist and steer configuration.

Control Demands

In a manned aircraft the manœuvre is limited partly by the power available and partly by the physical sensations which the pilot experiences. It is thus possible to design an airframe which is sufficiently strong to withstand the loads arising from the limited manœuvre.

The guidance and control system of a missile must be equipped with a device to ensure that the guidance demands are ignored, or reduced, when they would result in a manœuvre greater than that for which the airframe has been designed. This device consists simply of gyros or accelerometers located so that missile motions in planes normal to the flight direction can be measured.

In the case of a missile having cruciform wings it is possible aerodynamically to pull approximately $\sqrt{2}$ times the acceleration obtainable in a wing plane when the missile is manœuvring at 45° to this plane. This is simply due to the additional projected wing area, and would impose correspondingly higher loads upon the body. A device is sometimes incorporated in

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CONTROL LOCATION Fig. 12.

the missile to limit the manœuvre to a constant value in any normal plane, regardless of wing location.

A further possibility is to provide measuring units which restrict the bending moment and torque on control shafts and the like to a given maximum value.

Methods of Control

The manœuvre required of the missile is normally initiated by the development of appropriate aerodynamic forces or the use of jet thrust. The more important ways of doing this are as follows:—

(a) TRAILING-EDGE CONTROL SURFACES. These are used on conventional aircraft and have been retained on missiles of the pilotless bomber type, and certain others. The chief disadvantage is that there is a serious loss of effectiveness in the transonic and supersonic ranges and they are thus largely restricted to subsonic missiles. In addition the problem of installing the necessary operating mechanism in a thin aerofoil is formidable. Both the Regulus 1 and the Vickers 891 have trailing-edge controls.

(b) MOVING WINGS. Movement of the whole lifting surface overcomes the loss of effectiveness and when the wing is so used additional advantages are obtained. It is possible to get more rapid response due to the large forces available and by arranging for body incidence to be kept at approximately the zero value, drag is considerably reduced. This last fact is also advantageous if air-breathing engines are mounted on the body since the intake is not subjected to any undue incidence.

On the other hand the mechanical problem of installing the large actuators necessary to move a complete wing with the consequent weight penalty, and the loss of lift off the body which may be substantial, must be faced up to. Bloodhound is fitted with moving wings.

(c) MOVING WING TIPS. This is a compromise aimed at avoiding the excessive penalties which are incurred by large all-moving wings. Some of the advantages of moving wings are lost and the installation of the operating mechanism is a considerable problem. Bomarc has moving wing tips but since the tail fins also move they are presumably used only for roll control.

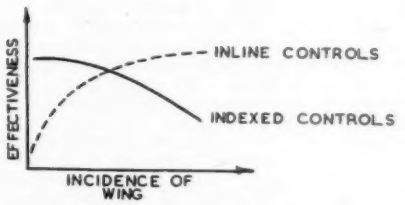
(d) MOVING CONTROL FINS. Whilst being similar to the moving wing in effectiveness the control fin does not have such rapid response characteristics and fuselage drag reduction is not obtained since both the main lifting surfaces and the body must pitch up to incidence together. However, the control actuators will be much smaller and the weight penalty much less. The fin may be located in the air stream or jet efflux. There are numerous examples of this type of control.

(e) SPOILERS. These are essentially aerodynamic surfaces which yield control force by means of drag rather than lift. Since the control on a missile is used throughout the flight, the use of spoilers would result in a considerable loss in performance, especially range. Probably the most important application is, therefore, in some small short-range missiles where the simplicity of a "bang-bang" spoiler system outweighs the results of the inherent drag. The spoiler is oscillated from one extreme position to the other and control is obtained by holding it at the appropriate extreme as long as is necessary. The German X4 missile used this type of control.

(f) CONTROLLED JET EFFLUX. Either the whole combustion chamber can be tilted or small subsidiary jets with controlled flow can be used. Such a control method involves considerable mechanical problems but is the only device suitable for operation at high altitude. The Thor and Atlas used tilting combustion chambers whilst the S.S.11 has subsidiary jets.

Location of Control Fins

When all-moving control fins are used there are certain possible variations in their location relative to the wings. The conventional location is aft of the wings and in this case the initial force due to control is opposite to that required to manœuvre the missile in the desired direction, as is indicated in Fig. 11. As a result of this there is a loss in response.



CONTROL EFFECTIVENESS Fig. 13.

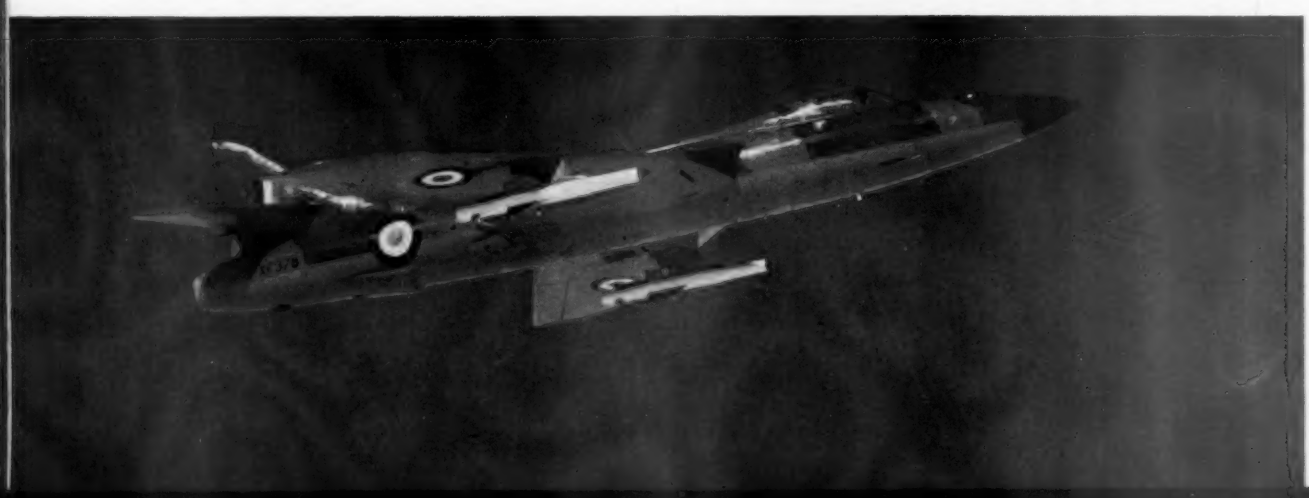
This disadvantage can be overcome by using nose, or canard-type, controls where the opposite is true as Fig. 11 shows. Unfortunately nose controls give rise to downwash effect over the main wing surfaces which reduces the lift obtainable from them especially when the missile is at high incidence. There may also be difficulties with roll control and thus nose controls possess very severe limitations when used on missiles designed to obtain maximum manœuvre at high incidence. In these circumstances tail controls are usually preferred. A rather inefficient compromise would be to use nose controls for pitch and yaw and tail, or wing, controls for roll.

A further possible variation of control position is in location round the body relative to the wings. The two most usual possibilities are shown in Fig. 12. The fins can either be placed in line with the wings or indexed at 45° to them, a location sometimes known as "interdigitated" fins.

Generally the in-line position suffers less from wing downwash interference at high incidence whilst the opposite is true at low incidence as can be seen by Fig. 13, but in practice the effect depends very much on the individual missile configuration. Fireflash has the fins indexed, whilst Firestreak has them in line.

When the missile is similar in layout to a conventional aircraft and is fitted with swept-back wings it is usually possible to eliminate the horizontal tailpane, as on Regulus 1 and Snark, unless it is needed for control, as on Regulus 2.

A Hawker Hunter 6 equipped with two de Havilland Firestreak air-to-air missiles. Firestreak uses a passive homing system.



A SUMMARY OF GUIDED WEAPONS

In the following tables, data are given on 97 of the World's current guided weapons that are either in production or undergoing active development; for convenience they have been listed under types. Also included on the third page, is a smaller, separate, table of 25 of the more important research rockets and test vehicles associated with guided missile development. The data included in these tables are based on published information from a number of sources—and, inevitably, there are gaps where the data is restricted or where reliable information is not available. Wherever possible, in the various sections, similar missiles are grouped together.

Designation	Country	Contractor	User	Status	Guidance	Main powerplant		Boost		Weight†	Dimensions—ft.			Range	Max. Mach No.	Remarks
							lb.		lb.	lb.	Length†	Dia.	Span	miles		
AIR-AIR																
Fireflash	U.K.	Fairey	R.A.F.	Op.	BR	None	—	2 SR			7.4	0.46	2.32		2.0	6/12/57.
MM-1	Japan	Mitshubishi			BR	1 SR				45	5.0					
Sparrow 1	U.S.A.	Sperry	U.S.N.	Op.	BR	1 SR		None	—	300	11.6	0.67	3.0		2.5	3/1/58.
Sparrow 3*	U.S.A.	Raytheon	U.S.N.		H	1 SR		None	—	350	11.0	0.67	3.33			*Also Sparrow 2.
5103	France	S.N.C.A.N.		Dev	Com.	1 SR		None	—	287	8.25	0.85	3.0	2.5	1.7	Tailless cruciform.
C7	Italy	Contraves		Dev.	IR	1 SR		None	—		7.9	0.4	1.5			Twist and steer.
Sidewinder	U.S.A.	Philco	U.S.N.	Op.	IR	1 SR		None	—	155	9.08	0.42	1.75		2.5	6/12/57.
Diamondback	U.S.A.	Philco		Dev.	IR											Sidewinder development.
M100A	Russia			Prod.	IR	1 SR		None	—		8.0*	0.75*		5*		*Approx.
Firestreak	U.K.	de Havilland	R.A.F.	Prod.	IR	1 SR		None	—		10.0	0.75	2.5			6/12/57.
M.O.51	France	Matra		Dev.	Optical	1 SR		None	—	350	10.0	1.05	3.3	5	1.5	14/2/58.
Falcon	U.S.A.	Hughes	U.S.A.F.	Op.	SAH*	1 SR		None	—	100	6.5	0.53	1.67			3/1/58—*also IR.
888	U.K.	Vickers	Cancelled			1 SR		None	—		16.1	1.04	3.75			14/2/58.
304	Sweden	G.W.B.				1 SR		None	—		14.0	1.5	7.0			Twist and steer.
TMA-1	Japan	Mitshubishi								235	9.5	0.5			1.6	
Zuni	U.S.A.		U.S.N.	Prod.	None					107	9.0	0.4			3.0	Multiple launcher.
Genie	U.S.A.	Douglas	U.S.A.F.	Op.	None	1 SR		None	—		10.0	1.5	4.0		1.5	Atomic warhead.
AIR-SURFACE																
Bullpup	U.S.A.	Martin	U.S.N.	Prod.	Com.	1 SR		None	—	540	11.0	1.0	3.15		1.8	3/1/58.
B.B.10	France	Sud-Aviation			Tele.	1 SR				900	11.0	2.7				Nose controls.
Rascal	U.S.A.	Bell	U.S.A.F.	Prod.	Inertial*	3 LR	12,000	None	—		30.0	4.0	14.0	100	1.5	6/12/57. *Terminal H.
Wagtail	U.S.A.	Minneapolis-Honeywell	U.S.A.F.		Inertial											
Corvus	U.S.A.	Temco		Dev.												
Hound Dog	U.S.A.	North American Aviation	U.S.A.F.	Dev.		TJ (J52)					40.0					For B-52.
(Stand-off-bomb)	U.K.	A. V. Roe	R.A.F.													For V-bombers.
Crossbow	U.S.A.	Northrop		Dev.	H*											*Homes on enemy radar.
Green Quail	U.S.A.	McDonnell	U.S.A.F.	Dev.												Decoy missile.
ANTI-SUB.																
Petrel	U.S.A.	Fairchild	U.S.N.	Op.	AH	1 TJ	1,000	None	—	3,800	24.0	2.0	13.0		0.7	3/1/58.
Rat	U.S.A.	Clevite	U.S.N.	Prod.	H*	1 SR		None	—	450	16.0	0.84	2.7		<1.0	Boosted torpedo. *Acoustic.
Asroc	U.S.A.	Minneapolis-Honeywell														Also Astor and Subroc.
SURFACE-AIR																
SAX-5	U.K.	Short				1 SR					6.5	0.78	2.6			
Parca	France	D.E.F.A.			Com. L	1 LR		4 SR		2,200	16.7	1.6	5.3		1.7	
‡M2	Russia				Com. L			1 SR			21.0	1.5	5.5			
Nike Ajax	U.S.A.	Douglas	U.S. Army	Op.	Com. L	1 LR	2,600	1 SR		1,000	21.0	1.0	4.5	20	2.0	14/3/58.
Nike Hercules	U.S.A.	Douglas	U.S. Army	Prod.	Com. L	1 SR		4 SR			27.0	2.5	6.0	40	2.3	6/12/57.
Nike Zeus	U.S.A.			Dev.												Anti-ballistic missile.
54	Switzerland	Oerlikon			BR	1 LR	*2,205	None	—	825	19.7	1.3	4.7	12	1.8	3/1/58. *For 30 sec.
56	Switzerland	Oerlikon			BR	1 LR	*2,200	None	—	820	19.7	1.3	4.7		2.3	Improved 54. *For 35 sec.
Terrier 1	U.S.A.	Convair	U.S.N.	Op.	BR	1 SR		1 SR		1,000	14.8	1.15	4.0	12	2.0	3/1/58.
Terrier 2	U.S.A.	Convair	U.S.N.	Prod.	BR	1 SR								20		Improved Terrier.
Tartar	U.S.A.	Convair	U.S.N.	Prod.		1 SR								10		Smaller version of Terrier.
Seaslug	U.K.	Armstrong Whitworth	R.N.			1 SR		4 SR			20.0	1.5	4.75			6/12/57.

Abbreviations.—Op., operational; Dev., development; Prod., production; LR, liquid rocket; SR, solid rocket; TJ, turbojet; RJ, ramjet; PJ, pulsejet; Com., command; Com-L, command link; BR, beam rider; H, homing; AH, active homing; SAH, semi-active homing; IR, infra-red homing; Tele., television and link; Stel.-I, stellar-inertial.

† Weights and lengths are for basic missile unless otherwise stated. * See remarks column. ‡ Probable designations of Russian missiles shown in Moscow last November. Dates in remarks column refer to issue of *The Aeroplane* containing appropriate data sheet and illustrations.

Current Guided Weapons . . . .

Designation	Country	Contractor	User	Status	Guidance	Main powerplant	lb.	Boost	lb.	Weight†	Dimensions—ft. Length†	Dia.	Span	Range	Max. Mach No.	Remarks
Surface-Air—*contd.*										lb.				miles		
Bloodhound	U.K.	Bristol	R.A.F.		SAH	2 RJ	8,000	4 SR		2,000	22.0	1.75	9.2		2.5	6/12/57.
Thunderbird	U.K.	English Electric	Army*		SAH	1 SR		4 SR			20.0	1.6	5.0			6/12/57—*also R.A.F.
Hawk	U.S.A.	Raytheon	U.S. Army	Prod.	SAH	1 SR		None	—		17.0	1.2		20		Low level defence.
4300	France	S.N.C.A.S.E.				1 LR		1 SR		2,200	14.0	2.0	11.0		2.0	Tailless cruciform.
AR1S	Italy	Motofides				1 LR										Intermediate range.
MR27	Italy				Com.					53	5.0			20	1.5	
Maruca	France	S.N.E.C.M.A.	Navy					4 SR			20.0*					Used for training. *Approx.
Masurca	France	S.N.E.C.M.A.	Navy													Op. version of Maruca.
Talos	U.S.A.	Bendix	U.S.N.*	Prod.	BR+H	1 RJ		1 SR		3,000	21.0	2.5	9.0	43		14/3/58. *Also U.S. Army.
Bomarc	U.S.A.	Boeing	U.S.A.F.	Prod.	Com.+H	2 RJ	10,000	1 LR*		8,500	47.0	3.0	18.2	250	2.5	3/1/58. *Internal.
Bull Goose	U.S.A.	Fairchild	U.S.A.F.	Prod.		1 TJ (J83)										Decoy missile.
ANTI-TANK																
SS 10	France	S.N.C.A.N.	Army	Op.	Wire	1 SR		None	—	34	2.8	0.6	2.5	1	0.25	14/3/58.
SS 11	France	S.N.C.A.N.	Army	Dev.	Wire*	1 SR				40	4.0	0.6	2.15	2.5	0.6	*SS22 is radio.
Cobra 4	Switzerland	Contraves			Wire	1 SR				24	2.8	0.3	2.5	0.8	0.25	Cruciform tailless.
891	U.K.	Vickers		Dev.	Wire	1 SR		None	—		2.7	0.38	0.92		<1.0	14/3/58.
Redeye	U.S.A.	Convair			IR											Infantry weapon.
Malkara	Australia				Wire											Cruciform.
	U.K.		Army													Announced in 1957.
Dart	U.S.A.	Aerophysics	U.S. Army	Prod.	Wire	1 SR		None	—	300	5.0	0.75	4.5	3	0.8	14/3/58.
Lacrosse	U.S.A.	Martin	U.S. Army	Prod.	Com.	1 SR		None	—	1,200	18.0	1.5	9.0	8	<1.0	3/1/58.
	Japan	Kawasaki									3.3					
SURFACE-SURFACE																
4200	France	Sud Aviation			Com.	1 RJ		2 SR		660*	10.0	2.2	7.1	60		Twist and steer. *Launch wt.
Matador	U.S.A.	Martin	U.S.A.F.	Op.	Com.	1 TJ	3,700	1 SR		12,000	39.5	4.5	28.7	600	0.9	3/1/58.
Mace	U.S.A.	Martin	U.S.A.F.	Prod.	Inertial	1 TJ	3,700	1 SR						650	0.9	
Snark	U.S.A.	Northrop	U.S.A.F.	Op.	Stel.-I	1 TJ	11,000	2 SR	260,000*	35,000	69.0	5.0	42.0	5,000	0.9	6/12/57. *For 4 sec.
Regulus 1	U.S.A.	Vought	U.S.N.	Op.	Com.	1 TJ	4,600	2 SR		12,000	33.0		21.0	500	0.9	
Regulus 2	U.S.A.	Vought	U.S.N.	Prod.	Com.	1 TJ	12,000	1 SR	115,000*	26,000	57.0	6.0	20.0	800	1.5	6/12/57. *For 4 sec.
J2	Russia			Op.		1 TJ		2 SR			35.0*		22.0*	500*	0.8*	*Approx.
J3	Russia			Prod.		1 TJ		4 SR			35.0*		22.0*	450*	1.3*	*Approx.
315	Sweden	G.W.B.	Navy			1 PJ		4 SR*			26.0	2.2	8.5			*Internal.
Navaho	U.S.A.	N.A.A.	Cancelled		Inertial	2 RJ		3 LR*	135,000		70.0	6.0	29.0	5,000	3.0	Twist and steer. *For 45 sec.
Triton	U.S.A.	McDonnell	Cancelled		Inertial	RJ		SR		20,000	45.0	5.0		1,500	3.5	" Bumblebee " project.
Malafac	France															Ship–Ship.
Ballistic Weapons																
Corporal	U.S.A.	Firestone	U.S. Army*	Op.	Com.	1 LR		None	—	12,000	45.0	2.5	6.0	100	3.0	6/12/57. *Also British Army.
Sergeant	U.S.A.	Sperry	U.S. Army	Prod.	Inertial	1 SR		None	—		34.0	3.0	8.0	75		To replace Corporal.
	U.K.		Army			SR										Announced in 1958.
‡T7A	Russia					LR		None	—		35.0	3.0	7.0	30		
Redstone	U.S.A.	Chrysler	U.S. Army	Prod.	Inertial	1 LR	70,000	None	—		63.0	6.0	12.0	200	4.0	Nose separates.
T1	Russia					LR		None	—		50.0*	5.5*				*Approx.
Pershing	U.S.A.	Martin	U.S. Army	Dev.		1 SR								500		To replace Redstone.
‡T2 (M103)	Russia					1 LR	77,000			50,000	67.0	5.3	11.0	400		14/2/58.
Jupiter	U.S.A.	Chrysler	U.S. Army	Dev.	Inertial	1 LR	165,000	None	—	105,000	62.0	9.0		1,500	12.0	
Thor	U.S.A.	Douglas	U.S.A.F.	Prod.	Inertial	1 LR	165,000	None	—	110,000				1,500		
Polaris	U.S.A.	Lockheed	U.S.N.	Dev.	Inertial	SR				28,000	47.0			1,500		Submarine launched.
Minuteman	U.S.A.		U.S.A.F.	Dev.		SR*								5,000		*3-stage, general purpose.
	U.K.	de Havilland	R.A.F.											2,000		Announced in 1957.
Atlas	U.S.A.	Convair	U.S.A.F.	Dev.	Com.	1 LR	65,000	2 LR	165,000	240,000*	80.0	10.0		5,500	20.0	*Launch weight.
Titan	U.S.A.	Martin	U.S.A.F.	Dev.	Inertial					220,000*				5,500	20.0	*Launch weight.
T3	Russia					LR					100.0*			5,000		*Approx.
Honest John	U.S.A.	Douglas	U.S. Army	Op.	None	1 SR		None	—	6,000	27.2	2.5	8.0	15	2.0	14/2/58.
Little John	U.S.A.	Emerson	U.S. Army	Dev.	None	1 SR		None	—		12.0	1.0	2.5	10		
‡T5B	Russia				None	1 SR		2 SR			30.0	2.5	5.0	16		Also T8.
Comet 1, 2	Russia															Submarine launched.
RECONNAISSANCE																
SD 1	U.S.A.	Radioplane	U.S. Army	Prod.	Radio	1 Piston engine				375	13.1	1.0	13.1	540		
SD 3	U.S.A.	Republic	U.S. Army	Prod.		1 Piston engine										Twin boom layout.
	U.S.A.	Fairchild	U.S. Army	Dev.												Delta.
Pied Piper	U.S.A.	Lockheed	U.S.A.F.	Dev.												Recon. satellite.

Abbreviations.—Op., operational; Dev., development; Prod., production; LR, liquid rocket; SR, solid rocket; TJ, turbojet; RJ, ramjet; PJ, pulsejet; Com., command; Com-L, command link; BR, beam rider; H, homing; AH, active homing; SAH, semi-active homing; IR, infra-red homing; Tele, television and link; Stel.-I, stellar-inertial.

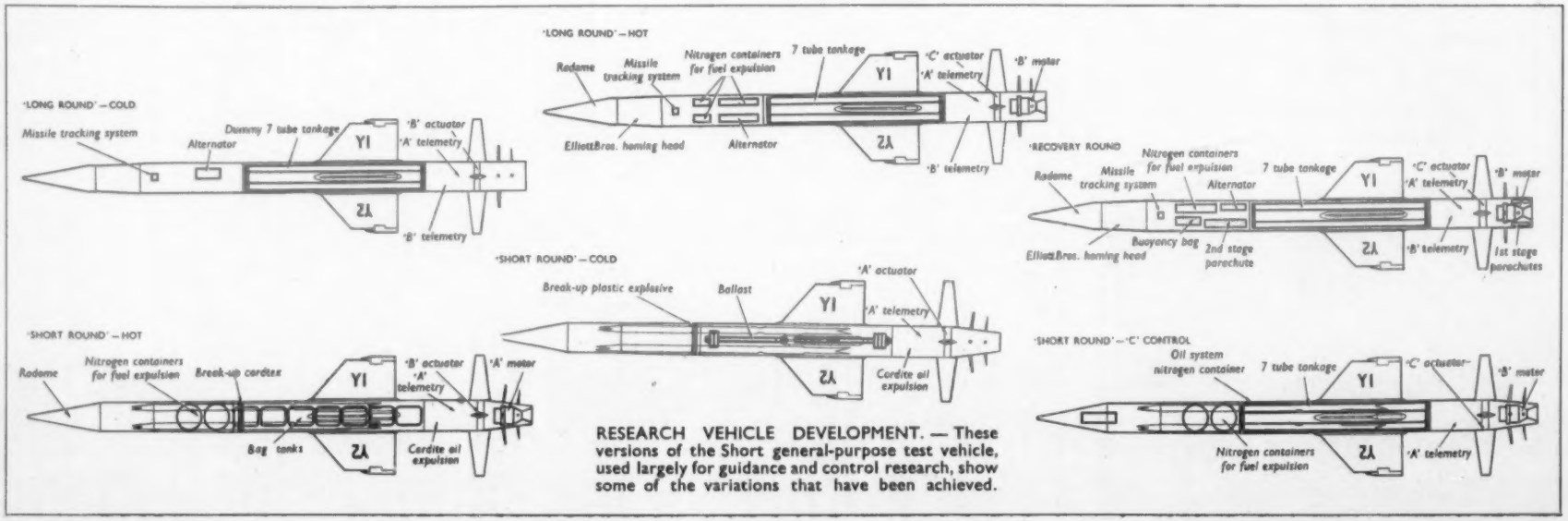
† Weights and lengths are for basic missile unless otherwise stated. * See remarks column. ‡ Probable designations of Russian missiles shown in Moscow last November. Dates in remarks column refer to issue of *The Aeroplane* containing appropriate data sheet and illustrations.

Current Guided Weapons . . . .

RESEARCH ROCKETS AND TEST VEHICLES

Designation	Country	Contractor	User	Powerplant†	Payload lb.	Weight‡ lb.	Dimensions—ft. Length‡	Dia.	Height miles	Remarks
G.P.V.	U.K.	Shorts	M.o.S.	1 LR+8 SR			25.5	1.44		3/1/58. Homing guidance.
Deacon	U.S.A.	Allegheny	NACA	1 SR 5,700 lb. for 3.5 sec. (Dan has Nike boost)	30	155	9.2	0.5	20*	*Dan altitude is 60 miles
Rockoon	U.S.A.	Allegheny	NACA	1 SR 5,700 lb. for 3.5 sec.	30	200		0.5	90	Balloon-launched Deacon.
Hasp	U.S.A.		U.S.N.	1 SR			6.0	0.3	20	Development of Loki.
Wasp	U.S.A.	Cooper	U.S.N.	1 SR		29	8.5	0.25	28	
Asp	U.S.A.	Cooper	U.S.N.	1 SR 5,850 lb. for 6 sec.	25	245	12.0	0.54	38	
Kappa 128JS	Japan				15	88		0.42	80	M=3.0.
Monica 1	France			SR	33	154	11.9	0.5	25	Also Monica 2, 3 and 4.
Veronique NA	France	L.R.B.A.		1 LR 8,820 lb. for 45 sec.	130	3,180	24.0	1.8	84	3/1/58. Also type N.
Terrapin	U.S.A.	Republic	NACA	1 SR+1 SR	8	224	14.7	0.5	76	M=6.0.
Aerobee	U.S.A.	Aerojet	*	1 LR 4,000 lb. max. for 45 sec.+1 SR 18,000 lb. for 2.5 sec.	150	1,690	26.0	1.25	70	14/2/58. M=4.0.
Aerobee-Hi	U.S.A.	Aerojet	*	1 LR 4,100 lb. max. +1 SR 18,000 lb. for 2.5 sec.	180	1,860	28.0	1.25	170	*U.S. Army, Navy and Air Force.
Skylark	U.K.		M.o.S.	1 SR 11,000 lb. for 35 sec.*	100	2,560	25.7	1.47	76	14/2/58—*Boost may be used.
Cajun (Nike)	U.S.A.		U.S.A.F.	1 SR 8,300 lb.+Nike Ajax boost	40	1,550	26.0		100	M=6.0.
Rockaire	U.S.A.	Douglas	U.S.A.F.	1 SR 7,800 lb. for 2.15 sec.	40	182	8.9	0.7	100	Air launched at 7 miles alt.
POL 1	Russia			1 SR 1,600 lb. for 4.5 sec.	9	500	13.0	0.8		
POL 2	Russia			4 SR 19,000 lb. total for 40 sec.	100	5,000	25.0	2.2	100	
Iris	U.S.A.	Atlantic	U.S.N.	SR (burns for 40 sec.)	100	1,000	16.0	1.0	200	
HTV	U.S.A.	Aerophysics	U.S.A.F.	4 SR+7 SR		230	13.0	0.75		M=10—Hypersonic Test Vehicle.
	France	O.N.E.R.A.		3 stage			20.0			Hypersonic Test Vehicle.
Farside	U.S.A.	Aeronutronic	U.S.A.F.	1 SR+4 SR+1 SR+4 SR (160,000 lb. total over 26 sec.)	3.5	1,900	23.0	2.0	4,000	Balloon launched.
T3A	Russia			3 or 4 stage LR based on T3	180				200*	*Orbit.
Jupiter C	U.S.A.		U.S. Army	1 SR+3 SR+11 SR+1 LR 83,000 lb. for 150 sec.	18	65,000	70.0	6.0	1,000*	14/2/58. *Orbit, M=25.
Vanguard	U.S.A.	Martin	U.S.N.	1 SR+1 LR 7,500 lb.+1 LR 27,000 lb.	24*	22,600	72.0	3.75	300*	14/2/58. *Estimated orbit.
X 17	U.S.A.	Lockheed		1 SR+3 SR+1 SR (based on Sergeant)		12,000	40.0	3.0		Re-entry test vehicle M=15+.

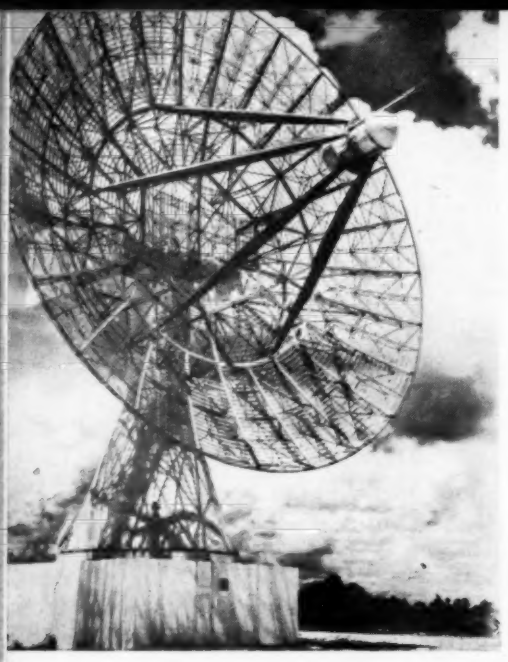
Abbreviations.—LR, liquid rocket; SR, solid rocket.
† Final stage is given first, initial boost last.
‡ Weights and lengths are for launching configuration.
* See remarks column. Dates in remarks column refer to issue of *The Aeroplane* containing appropriate data sheet and illustrations.



RESEARCH VEHICLE DEVELOPMENT. — These versions of the Short general-purpose test vehicle, used largely for guidance and control research, show some of the variations that have been achieved.

Missiles and Astronautics . . . .

A Directory of Missile Companies*



Missile-tracking antenna at the Cape Canaveral test range.

AUSTRALIA

Government Aircraft Factory, Fishermen's Bend, Port Melbourne, Victoria.
Development of the wire-guided Malkara infantry anti-tank SSM†.

CANADA

Avro Aircraft, Ltd., Malton, Ontario.
System manager for the Sparrow 2 AAM which is to be produced for the R.C.A.F. in place of the Canadian Velvet Glove AAM, whose development was cancelled.

Canadair, Ltd., P.O. Box 6087, Montreal, Quebec.
Co-ordinating contractor for the Sparrow 2 AAM for the R.C.A.F. with overall responsibility for the manufacture, assembly and flight testing of the missile.

Canadian Westinghouse Co., Ltd., Electronics Division, Plant No. 2, Hamilton, Ontario.
Guidance contractor for the R.C.A.F. Sparrow 2 AAM.

FRANCE

D.E.F.A. (Direction des Etudes et Fabrication d'Armément), Versailles.
Development of the Parca SAM for the French Army and the Maruca and Masurca SAMs for the French Navy. Manufacture of the Entac SSM and ASM which can be used by infantry and also fired from helicopters against ground targets.

Nord-Aviation, 12bis Av. Bosquet, Paris, 7e.
Development of the wire-guided SS10 and SS11 ASM and SSM for the French Army and the Nord 5103 AAM for the French Air Force.

O.N.E.R.A. (Office National d'Etudes et de Recherches Aéronautiques), 25 Avenue de la Division Leclerc, Chatillon-sous-Bagneaux (Seine).
Development of a three-stage ramp-launched hypersonic test vehicle.

S.E.P.R., 37 Rue des Acacias, Paris, 17e.
Development and production of the liquid- and solid-fuel rocket motors for Matra and Sud-Aviation SAMs.

Société Matra, 27 Quai de Boulogne, Boulogne S/Seine.
Development of the Matra M20, 051 and 510 AAMs which arm the French Mystère, Vautour, Trident and Durandal.

Sud-Aviation, 37 Bd. de Montmorency, Paris, 16e.
Development of the BB10 command-guided ASM for the French Air Force and the SE 4.200 SSM for the French Army.

GREAT BRITAIN

Aero Controls, Ltd., Industrial Estate, Weedon Road, Northampton.
Missile test gear and its instrumentation, centrifuges for applying accelerations up to 400*g*, loading and transport trolleys, servicing and maintenance structures.

Ardente Acoustic Laboratories, Ltd., 8-12 Minerva Road, North Acton, London, N.W.10.
Miniature electronic components.

Armstrong Siddeley Motors, Ltd., Parkside, Coventry.
Rocket-engine development; the company's rocket division was set up 12 years ago and has expanded steadily ever since. The company was the first in Britain to fly a liquid-fuel rocket motor.

Sir W. G. Armstrong Whitworth Aircraft, Ltd., Baginton, near Coventry.
Development and production of the Seaslug SAM for the Royal Navy. Seaslug is a beam-riding missile with an I.C.I. solid-fuel sustainer motor and four launching boost units. Four guided-weapon destroyers now under construction will be equipped with Seaslugs.

Automotive Products Co., Ltd., Brock House, Langham St., London, W.1.
Lockheed-Avery hoses and couplings, Purolator filters and high-precision components for missiles.

Avica Equipment, Ltd., Mark Rd., Hemel Hempstead, Herts.
Flexible pipe assemblies and bellows units for fuel lines and control systems.

Black Automatic Controls, Ltd., Leafield, Corsham, Wilts.
Pneumatic and hydraulic control valves and pressure and vacuum switches.

Boulton Paul Aircraft, Ltd., Wolverhampton.
Power controls and electronic research equipment.

Bristol Aero-Engines, Ltd., Filton House, Filton, Bristol.
Development and production of ramjet powerplants for missiles. Two 16-in. Thor ramjets power the Bloodhound SAM; the company has exhibited a larger and more powerful ramjet, the BRJ 801.

Bristol Aircraft, Ltd., Filton House, Filton, Bristol.
Development and production of the Bloodhound SAM in collaboration with Ferranti, Ltd. The Bloodhound employs semi-active homing and is in production for the R.A.F.; operational trials are to be made at the North Coates missile base.

British Thomson-Houston Co., Ltd., Rugby.
Development and production of the Sting-Ray high-powered ground-based radar for the Bloodhound and Thunderbird SAMs, which employ semi-active homing.

S. G. Brown, Ltd., Shakespeare St., Watford, Herts.
Guidance control equipment, missile control-surface actuators and airborne radar stabilizing equipment.

Bryans Aeroquipment, Ltd., 15 Willow Lane, Mitcham Junction, Surrey.
Instrument test equipment for missiles.

de Havilland Propellers, Ltd., Hatfield, Herts.
Development and production of the Firestreak AAM and a British IRBM. The infra-red homing Firestreak has a solid-fuel sustainer motor; it is in production for the R.A.F. and the Royal Navy.

Delaney Gallay, Ltd., Vulcan Works, Edgware Rd., London, N.W.2.
Production of heat-insulation blankets for a variety of missile applications.

Dunlop Rubber Co., Ltd., Aviation Division, Holbrook Lane, Foleshill, Coventry.
Missile components such as pressure-reducing and solenoid-operated valves.

Ekco Electronics, Ltd., Ekco Works, Southend-on-Sea, Essex.
Development and production of the fighter radar for the beam-riding Fireflash AAM.

Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13.
Development and production of missile servo systems, electric motors and

(*Continued on page* 595)

* Security necessitates some company omissions.
† Throughout this list the following abbreviations have been used to define the missiles concerned:—SSM—surface-to-surface missile. (This designation is applied both to cruise missiles and relatively short-range ballistic missiles.) IRBM—intermediate-range ballistic missile. ICBM — intercontinental ballistic missile. SAM — surface-to-air missile. AAM — air-to-air missile. ASM — air-to-surface missile. USM—underwater-to-surface missile. AUM air-to-underwater missile.

Missiles and Astronautics . . . .

(*Continued from page* 594)

printed circuitry besides instrumentation, system-simulation and data-recording equipment. The company produced a radar-homing head for the Short general-purpose vehicle.

E.M.I. Electronics, Ltd., Hayes, Middx.
Development and production of electronic equipment for missiles such as the Seaslug SAM.

English Electric Co., Ltd., Queens House, Kingsway, London, W.C.2.
Development and production of the Thunderbird SAM which is in production for the Army and the R.A.F. It has four boost motors and a solid-fuel sustainer; semi-active homing is employed.

Fairey Aviation Co., Ltd., Hayes, Middx.
Development and production of the beam-riding Fireflash AAM, the first British guided weapon to pass its Service acceptance trials. Fireflash has no sustainer motor and coasts to its target after being accelerated by two boost motors.

Ferranti, Ltd., Hollinwood, Lancashire.
Partner with Bristol Aircraft in the development of the Bloodhound SAM. Ferranti has been responsible for the design and production of Bloodhound's electronic and control systems.

Firth Cleveland Instruments, Ltd., Treforest, Pontypridd, Glam.
Gauges and flowmeters for liquid nitrogen and rocket fuels such as HTP and liquid oxygen.

G. Q. Parachute Co., Ltd., Stadium Works, Woking, Surrey.
This company has developed and produced parachutes for the recovery of supersonic missiles and test vehicles.

General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.
Main sub-contractor (with Sperry) for the guidance system of the beam-riding Seaslug SAM, which is in production for the Royal Navy.

Sir George Godfrey and Partners, Ltd., Hampton Road, West Hanworth, Middx.
This company, which specializes in air-conditioning equipment, has been associated with the development of the Royal Navy's Seaslug SAM.

Graseby Instruments, Ltd., Kingston By-pass Road, Tolworth, Surrey.
Production of test equipment for gyros such as those used in missile inertial-guidance systems and missile telemetry and control equipment.

High Duty Alloys, Ltd., Slough, Bucks.
Production of aluminium alloys with high strength at elevated temperatures for missile structures.

H.M.L. Engineering Ltd., Aircraft Division, 466-490 Edgware Rd., London, W.2.
Diesel- or electric-powered hydraulic test rigs used in missile development.

H. M. Hobson, Ltd., Hobson Works, Fordhouses, Wolverhampton.
Electro-hydraulic servo actuators, air/fuel ratio controls and gas-control valves for missile systems.

Honeywell-Brown, Ltd., 1 Wadsworth Rd., Perivale, Greenford, Middx.
Manufacturer of gyroscopes, accelerometers and instrumentation for missiles.

Hymatic Engineering Co., Ltd., Glover St., Redditch, Worcs.
Missile control valves and pressure-regulating equipment for operation over a wide range of temperatures and pressures.

Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1.
Development and production of solid-fuel rocket motors for such British missiles as the Seaslug SAM and the Vickers 891 infantry anti-tank SSM.

Integral, Ltd., Birmingham Road, Wolverhampton.
High-speed hydraulic pumps and motors for missile control systems.

Kelvin and Hughes, Ltd., Husun Works, New North Road, Barkingside, Essex.
High-frequency recording equipment for missile testing.

Laporte Chemicals, Ltd., Kingsway, Luton.
Production of HTP (high test peroxide) rocket-fuel oxidant.

Joseph Lucas (Gas Turbine Equipment), Ltd., Shaftmoor Lane, Birmingham, 28.
Missile fuel, hydraulic and combustion systems and their associated control gear.

Magnesium Elektron, Ltd., Clifton Junction, Manchester.
Production of magnesium-thorium alloys for missile structures.

Mallory Batteries, Ltd., Rainham Rd. South, Dagenham, Essex.
Development and production of miniature batteries for missile applications.

Marconi's Wireless Telegraph Co., Ltd., Marconi House, Chelmsford, Essex.
Guidance-system manufacturer for the Thunderbird SAM, which employs semi-active homing.

Marston Excelsior, Ltd., Fordhouses, Wolverhampton.
Fabrication and assembly of rocket test vehicles and production of missile radomes.

McMichael Radio, Ltd., Wexham Road, Slough, Bucks.
This company produces radio, electronic and electrical equipment and instrumentation; it is associated with the development and production of the Bloodhound SAM.

Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.
Early-warning and tactical-control radar, telemetry equipment and missile launchers.

M.L. Aviation Co., Ltd., United Buildings, Trading Estate, Slough, Bucks.
Design, development and manufacture of the launcher for the Bloodhound SAM and ground-handling equipment for Bloodhound and the Firestreak AAM.

Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1.
Development and production of the infra-red homing system for the Firestreak AAM, which is in production for the R.A.F. and Royal Navy.

D. Napier and Son, Ltd., 211 The Vale, Acton, London, W.3.
Development and production of rocket motors such as the NRE17 liquid-fuel missile engine, and ramjet test vehicles.

Northern Aluminium Co., Ltd., Bush House, Aldwych, London, W.C.2.
Aluminium alloy for missile structures.

Palmer Aero Products, Ltd., Penfold Street, London, N.W.8.
Production of flexible hose for missile applications.

Plessey Co., Ltd., Vicarage Lane, Ilford, Essex.
Development and production of receivers for the beam-riding Fireflash AAM and of iso-propyl-nitrate power-packs for missile auxiliary power.

Ransome and Marles Bearing Co., Ltd., Stanley Works, Newark-on-Trent.
Ball and parallel-roller bearings for missile applications.

Reid and Sigrist, Ltd., Braunstone Works, Leicester.
Development and production of missile instrumentation and gyro controls.

A. V. Roe and Co., Ltd., Greengate, Middleton, Manchester.
This company is reported to be responsible for the development and production of a British ASM, or stand-off bomb, which will be carried by the Vulcan and Victor strategic bombers.

Rolls-Royce, Ltd., P.O. Box 31, Nightingale Road, Derby.
It has been reported that Rolls-Royce is to produce the rocket motor for the British IRBM being developed by de Havilland Propellers. Rolls-Royce has a technical-assistance agreement with North American Aviation, whose Rocketdyne division produces rocket motors for U.S. ballistic missiles.

Rotax, Ltd., Chandos Rd., Willesden Junction, London, N.W.10.
Electrical generating and power systems for missile control.

Sangamo Weston, Ltd., Enfield, Middx.
Production of instruments used in missile development.

Saunders Valve Co., Ltd., Blackfriars Street, Hereford.
Development and production of control valves for rocket fuels such as HTP and liquid oxygen.

Self-priming Pump and Engineering Co., Ltd., Edinburgh Avenue, Trading Estate, Slough, Bucks.
Production of HTP pumps, control valves and pitch and yaw transducers for missile applications.

Short Brothers and Harland, Ltd., Queen's Island, Belfast, Northern Ireland.
Development and production of general-purpose vehicles for missile investigations. Examples are the Short GPV used in the development of systems for British SAMs and the SX.A5 multi-purpose surface-to-air test vehicle.

Missiles and Astronautics . . . .

Simmonds Aerocessories, Ltd., Treforest, Pontypridd, Glam.
Production of propellent gauges and flowmeters for HTP and liquid oxygen and nitrogen, and accessories such as stiffnuts and fasteners.

Solartron Electronic Group, Ltd., Thames Ditton, Surrey.
Production of electronic instrumentation for missile testing and development.

Sperry Gyroscope Co., Ltd, Great West Rd., Brentford, Middx.
Main guidance and control sub-contractor (with G.E.C.) for the A.W.A. Seaslug SAM. It has been reported that the company is responsible for the guidance system of the British IRBM under development by de Havilland Propellers.

Technograph Electronic Products, Ltd., 32 Shaftesbury Av., London, W.1.
Rigid or flexible printed circuits for guided missiles.

Teddington Aircraft Controls, Ltd., Merthyr Tydfil, Glam.
Production of potentiometers, accelerometers and pressure transducers for missile control and telemetry.

Venner Accumulators, Ltd., Kingston By-pass, New Malden, Surrey.
Production of silver-zinc accumulators used in Fireflash AAM development.

Vickers-Armstrongs (Aircraft), Ltd., At present under development is the Vickers 891 wire-guided anti-tank missile for infantry use. Vickers have also developed a series of missiles, now cancelled, such as the Red Dean AAM.

W. Vinten, Ltd., 715 North Circular Rd., London, N.W.2.
Manufacture of high-speed cameras for missile tracking.

ITALY

Contraves-Italiana, Rome.
Manufacture of the Contraves-Oerlikon 54 and 56 SAMs and the C.7 infra-red-homing AAM.

Whitehead-Motofides, Leghorn.
Development of the AR.15 SAM which has a liquid-fuel sustainer motor.

JAPAN

Fuji Precision Machinery Co., Ltd., Shuku-machi, Suginami-ku, Tokyo.
Rocket-motor contractor for the MM-1 AAM.

Kawasaki Aircraft Co., Ltd., P.O. Box 645, Kobe Central.
Development of an anti-tank SSM for infantry use.

Mitsubishi Electric Co., P.O. Box 188, Tokyo Central.
Guidance contractor for the Shin Mitsubishi MM-1 beam-riding AAM. Production under licence of the Contraves-Oerlikon 56 SAM.

Mitsubishi Heavy Industries, Reorganized, Ltd., Aircraft Dept., Head Office, No. 14, 2-chome Marunouchi, Chiyoda-ku, Tokyo.
Development of the command-guided TMB-0 research missile and the TMA-1 AAM.

Shin Mitsubishi Jukogyo K.K., P.O. Box 1030, Kobe Central.
Development of the beam-riding MM-1 AAM.

SWEDEN

Saab Aircraft Company, Linköping.
Production of Swedish AAMs and SAMs such as the Robots 304 and 315 developed by the Guided Weapons Bureau.

SWITZERLAND

Contraves A.G., Zürich 11/52.
Development and production of the Contraves-Oerlikon 54 and 56 beam-riding SAMs which are also being built under licence in Italy and Japan.

Oerlikon Machine Tool Works, Buhrle and Co., Zürich 11/50.
Development and production in conjunction with Contraves of the Contraves-Oerlikon 54 and 56 SAMs.

UNITED STATES OF AMERICA

AC Spark Plug Division, General Motors Corpn., 1300 N. Dart Highway, Flint 2, Michigan.
Contractor for the inertial-guidance systems of the Thor IRBM and the Mace SSM which are both in production for the U.S.A.F.

Aerojet-General Corpn., Azusa, Calif.
Propulsion contractor for the Sparrow I AAM, Nike Ajax SAM, Polaris USM, Titan ICBM and Bullpup ASM. The Sparrow I, Polaris and Bullpup have solid-fuel rocket motors.

Aerophysics Development Corpn., Subsidiary of the Curtiss-Wright Corpn., Santa Barbara, Calif.
Prime contractor for the Dart anti-tank SSM, which is in production for the U.S. Army. The company also has a contract for a development of the Dart.

American Bosch Arma Corpn., Arma Division, Roosevelt Field, Garden City, Long Island, New York.
Guidance contractor for the inertial systems of the Thor IRBM and the Titan ICBM, both for the U.S.A.F.; the Thor is in production and the Titan is under development.

Atlantic Research Corpn., 321 Montgomery Street, Alexandria, Va.
Prime contractor for the U.S. Navy's Iris research rocket. This has a solid-fuel motor which burns for 40 sec.; design altitude is 200 miles.

Bell Aircraft Corpn., Weapon Systems Division, P.O. Box 1, Buffalo 5, New York.
Prime, airframe, propulsion and guidance contractor for the Rascal ASM, which is in production for the U.S.A.F. Propulsion contractor for the U.S. Army Nike Ajax SAM.

Bell Telephone Laboratories, Inc., 463 West St., New York 14, New York.
Prime and guidance contractor for the U.S. Army Nike Ajax and Nike Hercules SAMs.

Bendix Aviation Corpn., Bendix Products Division—Missiles, 400-406 S. Beiger Street, Mishawaka, Indiana.
Prime and guidance contractor for the Talos SAM, which is in production for the U.S. Army and Navy. Talos is a ramjet-powered beam-riding missile with a homing head.

Boeing Airplane Co., Pilotless Aircraft Division, Box 3925, Seattle 24, Washington.
Prime and airframe contractor for the ramjet-powered Bomarc SAM, which is in production for the U.S.A.F.

California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.
Prime contractor for the U.S. Army Corporal and Sergeant SSMs. The Corporal is operational and the Sergeant, a development of it, is in production.

Chance Vought Aircraft, Inc., P.O. Box 5907, Dallas, Texas.
Prime and airframe contractor for the U.S. Navy's Regulus 1 and 2 SSMs. The Regulus 1 is subsonic and has a range of 500 miles; the Regulus 2 is supersonic, travelling at speeds up to Mach 1.5.

Chrysler Corpn., Missile Operations, Detroit, Michigan.
Prime and airframe contractor for the U.S. Army's Redstone SSM and Jupiter IRBM. Both have inertial guidance.

Convair-Astronautics, Division of General Dynamics Corporation, 3302 Pacific Highway, San Diego 12, Calif.
Prime contractor for the U.S. Navy's Terrier 1 and Tartar SAMs and the U.S.A.F.'s Atlas ICBM. The Terrier 1 is operational, the Tartar is in production, and the Atlas is under development.

Convair Division of General Dynamics Corpn., Pomona Division, 1675 W. 5th St., Pomona, Calif.
Airframe contractor for the U.S. Navy's Terrier 1 and 2 and Tartar SAMs. The Tartar is a smaller version of the Terrier.

Cornell Aeronautical Laboratory, Cornell University, Buffalo, 21, New York.
Prime contractor for the U.S. Army Lacrosse SSM. Radar command guidance is used for this missile, which is intended for attacks on enemy strongpoints.

Douglas Aircraft Co., Inc., Missiles Engineering Department, 3000 Ocean Park Blvd., Santa Monica, Calif.
Prime and airframe contractor for the Genie and Sparrow 2 AAMs, the Thor IRBM and the Honest John SSM. Airframe contractor for the Little John SSM, Sparrow 1 AAM and the Nike Ajax and Nike Hercules SAMs.

Emerson Electric Manufacturing Co., 8100 Florissant Avenue, St. Louis 21, Missouri.
Prime contractor for the Little John SSM, which is under development for the U.S. Army.

Fairchild Engine and Airplane Corpn., Guided Missiles Division, Wyandanch, Long Island, New York.
Prime, airframe and guidance contractor for the U.S. Navy Petrel AUM. Prime contractor for the Duck and Goose bomber-defence missiles.

Fairchild Engine and Airplane Corpn., Engine Division, Deer Park, Long Island, New York.
Propulsion contractor for the U.S. Navy Petrel AUM and the U.S.A.F. Goose bomber-defence missile.

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Farnsworth Electronics Co., Division of International Telephone and Telegraph Corpn., 3702 E. Pontiac St., Fort Wayne 2, Indiana.
Guidance contractor for the U.S. Navy Talos SAM.

Federal Telecommunication Laboratories, Division of International Telephone and Telegraphic Corpn., 500 Washington Ave., Nutley 10, New Jersey.
Guidance contractor for the U.S.A.F. Rascal ASM and the U.S. Army Lacrosse SSM. Guidance for the Rascal is inertial; command guidance is used for the Lacrosse.

Firestone Tire and Rubber Co., Guided Missile Division, 2525 Firestone Blvd., Los Angeles 54, Calif.
Airframe contractor for the U.S. Army's Corporal SSM.

Ford Instrument Co., Division of Sperry Rand Corpn., 31-10 Thomson Ave., Long Island City, New York.
Guidance contractor for the U.S. Army's Redstone SSM and Jupiter IRBM. Inertial guidance is used for both these missiles.

General Electric Co., 3198 Chestnut St., Philadelphia 4, Penn.
Airframe and guidance contractor for the U.S. Navy's infra-red homing Sidewinder AAM. Contractor for the inertial guidance systems of the U.S. Navy Polaris USM and the U.S.A.F. Atlas ICBM.

General Motors Corpn., Allison Division, Speedway, Indianopolis 6, Indiana.
Propulsion contractor for the U.S. Navy's Regulus I SSM and the U.S.A.F. Mace SSM. Both missiles cruise at Mach 0.9.

Gilfillan Brothers, Inc., 1815 Venice Blvd., Los Angeles 6, Calif.
Guidance contractor for the U.S. Army's Corporal SSM. The Corporal has command guidance.

Grand Central Rocket Co., Box 111, Redlands, Calif.
Prime and airframe contractor for the U.S. Navy's Asp research rocket. Propulsion contractor for the Dart anti-tank SSM which is in production for the U.S. Army.

Hercules Powder Co., Inc., 917 Market St., Wilmington 99, Delaware.
Propulsion contractor for the U.S. Army's Honest John SSM, which is an unguided artillery rocket.

Hughes Aircraft Co., Culver City, Calif.
Prime, airframe and guidance contractor for the U.S.A.F. Falcon 1 and 2 AAMs. Fire-control system contractor for U.S.A.F. Genie AAM, which has an atomic warhead.

M. W. Kellogg Co., Subsidiary of Pullman, Inc., Danforth Ave., Jersey City 3, New Jersey.
Propulsion contractor for the U.S. Navy's Terrier 1 SAM.

Lockheed Aircraft Corpn., Missile Systems Division, P.O. Box 504, Sunnyvale, Calif.
Prime and airframe contractor for the U.S. Navy's Polaris USM. The Polaris is under development; it has a solid-fuel motor and will be fired from submerged submarines.

Marquardt Aircraft Co., 16555 Saticoy St., Van Nuys, Calif.
Propulsion contractor for the U.S.A.F. Bomarc SAM, which is powered by two Marquardt ramjets.

Martin Co., Baltimore 3, Md.
Prime and airframe contractor for the U.S. Navy's Bullpup ASM, the U.S.A.F. Matador SSM and Titan ICBM. Prime contractor for the U.S. Navy's Vanguard satellite and airframe contractor for the U.S. Army Lacrosse SSM.

McDonnell Aircraft Corpn., Missile Engineering Division, Lambert-St. Louis Municipal Airport, Box 516, St. Louis 3, Missouri.
Prime contractor for the U.S.A.F. Green Quail ASM and propulsion contractor for the U.S. Navy's Talos SAM. Green Quail is a counter-measures decoy missile carried by bombers for their own protection.

Motorola, Inc., 2710 N. Clybourn Ave., Chicago 14, Ill.
Guidance contractor for the U.S.A.F. Bomarc and U.S. Navy Terrier 2 SAMs and the U.S. Army Jupiter ICBM.

Northrop Aircraft, Inc., Hawthorne, California.
Prime, airframe and guidance contractor for the U.S.A.F. Snark SSM. Airframe contractor for the U.S. Army Hawk 1 SAM. The Snark is a cruise missile and the Hawk is for defence against low-flying aircraft.

Pan-American World Airways, Guided Missiles Range Division, Air Force Missile Test Center, Patrick A.F.B., Fla.
Prime contractor to the U.S.A.F. for the management, operation and maintenance of the missile test centre at Patrick A.F.B.

Philco Corpn., 4700 Wissahickon Ave., Philadelphia 44, Penn.
Prime, airframe and guidance contractor for the U.S. Navy's infra-red-homing Sidewinder AAM, and its development, the Diamondback AAM.

Pratt & Whitney Aircraft, Division of United Aircraft Corpn., 400 Main St., East Hartford 8, Conn.
Propulsion contractor for the U.S.A.F. Snark SSM, which cruises at Mach 0.9.

Radio Corpn. of America, Missile and Surface Radar Dept., Marne Highway, Moorestown, New Jersey.
Guidance contractor for the Talos SAM, which is in production for the U.S. Army and Navy. Talos is a beam rider which homes on its target in the final phase of interception.

Radioplane, Division of Northrop Aircraft, Inc., 8000 Woodley Ave., Van Nuys, Calif.
Prime contractor for the Crossbow ASM, which homes on enemy radar.

Ramo-Wooldridge Corpn., 5730 Arbor Vitae St., Los Angeles 45, Calif.
Overall technical direction and systems engineering responsibility for U.S. IRBM and ICBM programmes.

Raytheon Manufacturing Co., 190 Willow St., Waltham 54, Mass.
Prime and guidance contractor for the U.S. Navy's Sparrow 3 AAM and the U.S. Army Hawk SAM, which uses semi-active homing.

Reeves Instrument Corpn., 215 E. 91st Street, New York 28, New York.
Guidance contractor for the U.S. Navy's Terrier I beam-riding SAM. The Terrier I is operational.

Republic Aviation Corpn., Guided Missiles Division, 223 Jericho Turnpike, Mineola, Long Island, New York.
Prime contractor for the NACA Terrapin research rocket.

Rocketdyne Division of North American Aviation, Inc., 6633 Canoga Park, Calif.
Propulsion contractor for the U.S.A.F. Genie AAM, the U.S. Army Redstone SSM and Jupiter IRBM and the U.S.A.F. Thor IRBM.

Ryan Aeronautical Co., 2701 Harbour Drive, San Diego 12, Calif.
Propulsion contractor for the U.S. Army Corporal SSM, which has a liquid-fuel rocket motor.

Sandia Corpn., Division of Western Electric Co., 195 Broadway, New York 7, New York.
Prime contractor for the Lulu AUM, which has an atomic warhead, and warhead contractor for the U.S.A.F. Thor IRBM and Titan ICBM.

Sperry Farragut Co., Division of Sperry Rand Corpn., Bristol, Tennessee.
Prime and guidance contractor for the U.S. Navy's Sparrow I beam-riding AAM. Sparrow has a solid-fuel rocket motor; it travels at speeds up to M 2.5.

Sperry Gyroscope Co., Division of Sperry Rand Corpn., Great Neck, Long Island, New York.
Prime and guidance contractor for the U.S. Navy's Sparrow I AAM. Guidance contractor for the U.S. Navy's Terrier II SAM and Regulus II SSM.

Stavid Engineering, Inc., U.S. Highway No. 22, Plainfield, New Jersey.
Guidance contractor for the U.S. Navy Regulus 2 SSM, which is command guided and has a range of 800 miles.

Temco Aircraft Corpn., P.O. Box 6191, Dallas 2, Texas.
Development of the Corvus ASM for the U.S. Navy.

Thiokol Chemical Corpn., Trenton 7, New Jersey.
Propulsion contractor for the U.S.A.F. Mace SSM and Falcon AAM, the U.S. Army Sergeant SSM, Nike Hercules, Lacrosse and Hawk SAMs and the NACA Terrapin research rocket.

Utica-Bend Corpn., Subsidiary of Curtiss-Wright Corpn., 50500 Mound Rd., Utica, Mich.
Airframe contractor for the U.S. Army Dart SSM.

H. A. Wagner Co., 14707 Keswick St., Van Nuys, Calif.
Guidance contractor for the U.S. Dart SSM, which is a wire-guided anti-tank missile.

Westinghouse Electric Corpn., Air Arm Division, Friendship International Airport, Baltimore 3, Md.
Guidance contractor for the U.S.A.F. Bomarc SAM. Command guidance with homing is used for Bomarc.

THE FIGHTING SERVICES

R.A.F. Staff College

AIR COMMODORE E. D. McK. NELSON, C.B., has been appointed Commandant of the R.A.F. Staff College, Andover. Commandant of No. 1 School of Technical Training, R.A.F. Halton, since May, 1956, he was previously on the directing staff of the R.A.F. Staff College, Bracknell. From January, 1953, to June, 1957, he was an A.D.C. to H.M. The Queen.

Wright Jubilee Trophy

THE fifth annual Flying Training Command contest for the Wright Jubilee Trophy is to be held at the Central Flying School, R.A.F. Little Rissington, on May 1. The trophy is competed for by flying instructors nominated to represent the R.A.F. College, Cranwell; The All-Weather Jet Refresher School at Strubby, and a number of Flying Training Schools.

Each pilot has to complete a compulsory sequence of set aerobatics and is allowed 2 min. for voluntary individual manœuvres. The Trophy, a silver cup, was presented to the R.A.F. in 1953 by the R.A.F. Association to commemorate the 50th anniversary of powered flight.

R.A.F. Regiment Competitions

STATIONED at R.A.F. El Adem, Libya, No. 62 (Field) Squadron, R.A.F. Regiment, commanded by Sqn. Ldr. J. R. Spencer, has won the Lloyds Cup for small-arms proficiency for 1957, the Squadron's second marksmanship victory of the year. It has already won the Harris Cup for 1957, which is awarded for competition between units in M.E.A.F.

No. 7 (Light Anti-Aircraft) Wing, R.A.F. Regiment, comprising Nos. 1, 31 and 32 (L.A.A.) Squadrons with 2nd T.A.F., has won the Craigs Trophy for mechanical transport efficiency for 1957. Presented in 1956 for annual competition between R.A.F. Regiment units in 2nd T.A.F., the trophy is to be transferred to M.E.A.F. this year for a similar competition.

New Commandant for Halton

AIR COMMODORE T. N. COSLETT, O.B.E., has become Commandant of No. 1 School of Technical Training at R.A.F. Halton. An aircraft apprentice at Halton over 30 years ago, and subsequently a graduate of the R.A.F. College, Cranwell, Air Cdre. Coslett was Senior Technical Staff Officer at Headquarters, Coastal Command, from February, 1957, until taking up his new appointment. Attending the Imperial Defence College in 1953, he later became Deputy Director of Engineering Plans at the Air Ministry.

Duncan Trophy

RECENTLY disbanded, No. 118 Squadron has won the 1957 Duncan Trophy air-firing competition for fighter squadrons in 2nd T.A.F. The trophy was to be presented to the former squadron commander, Sqn. Ldr. N. C. Buddin, by the C.-in-C., Air Marshal Sir Humphrey Edwardes-Jones, at R.A.F. Jever on April 22.

BRUTON ST. DINNER.—On April 9, as recorded in last week's issue, the Royal Air Force Club held a reunion for those members who had been on the Club's register prior to January 1922 when it moved from Bruton Street to Piccadilly.

Royal Air Force Appointments

THE following Royal Air Force appointments are announced:—

Wing Commanders: F. J. Cuthill to No. 2 Police District for Provost Duties; J. A. Sherry to Headquarters, Coastal Command, for technical staff duties; E. F. Wisdom to Headquarters, No. 40 Group, for air staff duties; A. E. Anderson to Air Ministry for duty in the Department of the Air Member for Personnel; A. S. Mohan to Air Ministry for duty in the Department of the Air Member for Supply and Organization; A. E. G. Pye to Headquarters, No. 3 Group, for technical staff duties; G. I. Pawson to R.A.F. St. Athan for administrative duties; W. L. Clarke to R.A.F. Sylt for technical duties; G. R. Cook to No. 113 M.U. to command; H. H. C. Hester to R.A.F. Little Rissington for technical duties.

Wing Officer F. R. Pentland, W.R.A.F., to Headquarters, Fighter Command, for administrative staff duties.

Squadron Leader A. J. Cunningham to Headquarters, M.E.A.F., for administrative staff duties (with acting rank of Wg. Cdr.).

Reunions

No. 601 Squadron, R.Aux.A.F.—The annual dinner will be held at the Windsor Castle, Vauxhall Bridge Road, London, S.W.1, on May 10. Tickets, price 15s. 6d., are available from Mr. H. R. Cooke, 43 Crown Rise, Garston, Watford, Herts.

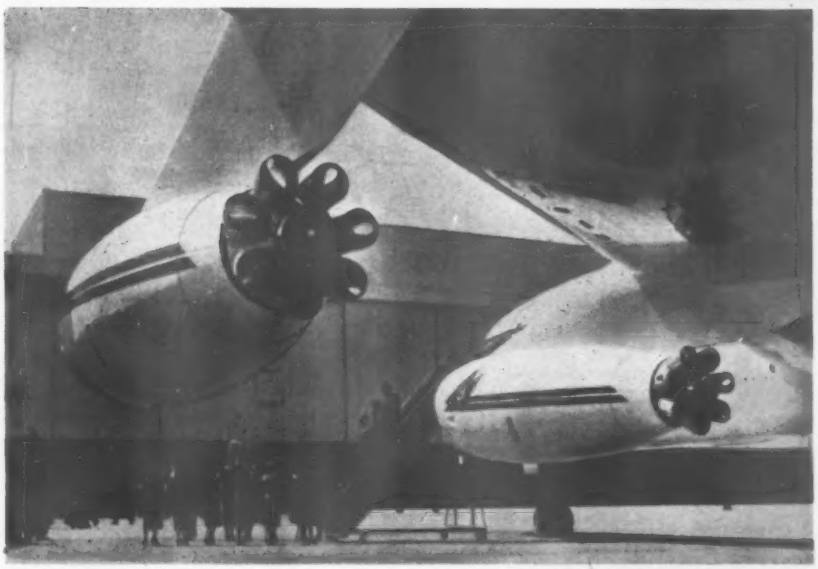
No. 60 Squadron.—The fifth officers' annual reunion will be held at the R.A.F. Club, Piccadilly, London, W.1, on Saturday, May 3. Details and tickets, price 13s. 6d., can be obtained from Wg. Cdr. R. V. Moxey, Air Ministry (Room 795), Awdry House, Kingsway, London, W.C.2.

QUEEN'S FLIGHT.—Two de Havilland Herons (XM 295 and XM 296) joined the Queen's Flight at R.A.F. Benson last week, bringing its total strength up to three Herons, three Vickers Vikings and one Westland Dragonfly. The new Herons, seen at D.H.'s Chester factory, are fitted with 140-channel VHF equipment with a 10-channel standby unit; radio compass; ILS, and a Decca Navigator.

NEWS IN PICTURES

A new gun pod mounting double-barrelled 20-mm. automatic cannon is seen (above) under a Douglas A4D Skyhawk of the U.S. Navy. It has been developed by the Navy Bureau of Ordnance and the aircraft division of the Hughes Tool Co.

Above, the first production Grumman WF-2 Tracer early-warning aircraft flew recently. The prototype seen here has its port propeller feathered.



Left, coupled with the sound suppressors at the rear of the Douglas DC-8's Pratt & Whitney JT-3C turbojets are thrust reversers to reduce the landing run.

Below, a close-up of the tail of the Fairey Rotodyne showing the folding fins. As we reported last week, transitional flights have now been made with this aircraft at White Waltham.

Photograph copyright "The Aeroplane"

Below, a new picture of the Czechoslovak Aero HC-2 Heli-Baby two-seater, which has an 80-h.p. Praga D engine. Note the dual cyclic-control stick.

Howard Levy photograph

Doppler Equipment Design

A PAPER describing the design features of the individual units of a Doppler-sensor, and the requirements of the computer and heading reference of Doppler navigation equipment, was given before members of the British Institution of Radio Engineers on April 15. Written by Mr. E. G. Walker, who has been concerned with airborne navigational equipment in the development laboratories of Marconi's Wireless Telegraph Co. at Writtle since 1950, the paper covers the considerations governing the choice of radio frequency, aerial-beam configuration, radiation power and other system parameters.

The first Doppler navigational equipment produced in this country was a pulse-system weighing about 250 lb. including computer, but excluding power supply and heading reference, and occupied a volume of 14 cu. ft. It consumed 750 W. and the aerial cut-out was 42 in. by 25 in. Comparable figures for the most recent navigator are 130 lb. weight, 3 cu. ft., 400 W. and an aerial cut-out of 26 in. by 20 in. Due to availability of microwave components the first Doppler-sensors used a 3-cm. wavelength and although some equipments have operated at other frequencies it is probable that sensors for civil use will standardize in the 3.33 to 3.53-cm. band.

An alternative to the gyro-magnetic compass, the limiting accuracy factor with Doppler navigators, is being developed in the Earth Rate Directional Reference which is an inertial system detecting the earth's rotational rate and indicating true north. It is independent of magnetic or variation data but requires compensating inputs of vehicle velocity and latitude, both of which can be supplied by the Doppler-sensor. The average expected accuracy over the latitude range 0 to 75° is 0.5°. Earth-rate-signal falls off with increasing latitude and the system is usable only up to ±75°, after this use is made of free-gyro mode, the accuracy of which is expected to be a whole order better than gyros in present use.

Prizes for Articles

EVERY year six premiums, each worth 25 guineas, are offered by the Radio Industry Council for articles published in the technical press during the year. The premiums are awarded for such articles as, in the opinion of the Council's panel of judges, are likely to draw attention of people all over the world to British leadership in the fields of radio, television and electronics.

On April 10 premiums were awarded to five winners as follows:

"Heat Control in Electronic Equipment," by E. N. Shaw, A.M.I.E.E. (R.R.E., Malvern)—**Electronic Engineering,** January/February/March, 1957.

"An Alternative Colour TV System," by E. J. Gargini (E.M.I. Research Department)—**Wireless World,** August, 1957.

"Cleaning by Ultrasonics," by L. Atherton, B.Sc., A.M.I.E.E. (Mullard, Ltd., Equipment Div.)—**British Communications and Electronics,** March, 1957.

"Speed Control in Industry," by E. J. P. Long, B.Sc. (Eng.), A.M.I.E.E., A.M.I.Mech.E. — **British Communications and Electronics,** November/December, 1957, January, 1958.

"Components for Printed Circuits," by L. W. D. Sharp, M.A., M.I.E.E. (The Plessey Co., Components Div.)—**British Communications and Electronics,** April, 1957.

A total of 53 articles published during 1957 were submitted together with five late entries from 1956.

It is surprising that more articles were not submitted, seeing that any writer is eligible who is not paid a salary wholly or mainly for writing and not earning 25% or more of his income from literary fees. Moreover, any number of articles may be submitted. It is noteworthy that no premiums were awarded for articles directly connected with aviation or aeronautical aspects.

Lecture on Powered Lift

BRITISH helicopter experts were out in force on April 11 for the lecture on "Powered Lift Systems" by DR. CHARLES H. ZIMMERMAN, aeronautical research engineer with the NACA at Langley Field. We summarized the lecture last week.

After his talk Dr. Zimmerman showed a film of some of the model tests made at Langley Field. These covered VTO and conversion tests with a deflected-slipstream flat-riser aircraft and also tests with models of the Hiller X-18 and Vertol 76 pivot-wing flat-risers. The Hiller model was seen taking off vertically and converting to forward flight in a wind-tunnel. A model of the Vertol pivot-wing aircraft was shown flying on a revolving-arm rig in the open air. The operators found that conversion from forward flight to vertical landing was more difficult than converting to forward flight after take-off.

Answering a question by MR. J. SHAPIRO, Dr. Zimmerman said that reasonably good correlation had been found between tests with the models and the behaviour of full-scale aircraft. Model controllability tests showed what could and could not be done with the full-scale aircraft; experience with the Convair Pogo VTO aircraft had proved the value of these tests.

Replying to MR. R. A. SHAW of the Ministry of Supply, Dr. Zimmerman said that one of the reasons for building the Vertol convertiplane was to study the problems of "flying on the back side of the power-required curve." The power required by such an aircraft decreased very rapidly with forward speed; thus during landing a gust might reduce forward speed suddenly and the power required would thus increase very rapidly.

A City Dinner

A LARGE company of Liverymen and their guests—who, in the words of one speaker, had every kind of claim to every kind of fame—foregathered in the Mansion House on April 14 for the annual Livery Dinner of the Worshipful Company of Coachmakers and Coach Harness Makers. Among them were the Chief of the Air Staff, Marshal of the Royal Air Force Sir Dermot Boyle; Air Chief Marshal Sir Frederick Bowhill; Air Marshal Sir John Baldwin; Air Vice-Marshal Sir William Cushion; Rear Admiral Sir Matthew Slattery; Sir Reginald Verdon Smith; Mr. Cyril Uwins, and many other distinguished members of the Services and the aircraft industry.

In proposing the toast to the Lord Mayor and the Corporation of London and the Sheriffs, the RT. REV. BISHOP H. A. WILSON, C.B.E., D.D., Honorary Chaplain to the Company, commented that London's Lord Mayor was the "greatest civic dignitary in the World." He spoke of the trend toward a difference in outlook at the present time from that of past generations when "patriotism and dignity of work were outstanding qualities." Continuity with the past, he said, was a precious thing and if we could hold on to that we could retain our strength and vigour as a nation.

In reply the Lord Mayor, SIR DENIS H. TRUSCOTT, T.D., commented on the remarkable "galaxy of senior officers of Her Majesty's Forces" that was present and suggested that a suitable subject for the agenda for the next Chiefs of Staffs Committee would be the determination of an appropriate collective noun. In speaking of various charitable institutions he said that none was more deserving than the Soldiers', Sailors' and Airmen's Families Association. And he paid a nice compliment to the Worshipful Company by saying that he was honoured that the Master had asked for the dinner to be held in the Egyptian Hall of the Mansion House.

The toast to the Company was proposed by the Renter Warden, the HON. DENIS BERRY, T.D., who had some nice things to say about the Master, Mr. R. J. D. Smith, who is also the Company's Clerk. He was in fact, he said, the 17th Clerk and the second to become Master.

In reply, MR. R. J. D. SMITH spoke of the Company's aeronautical affiliations. As long ago as 1909 it had been sufficiently airminded to send a message of congratulations to Blériot. That was the year that Mr. (now Sir Frederick) Handley Page formed the first aircraft manufacturing company in this country. And within a few years members of the aircraft industry were admitted to the Worshipful Company—which had progressed from the Barouche to the Britannia.

MAJOR R. H. THORNTON, M.C., J.P., M.A.—always a speaker worth listening to—excelled himself in his toast to the guests. Unfortunately, so far as we were concerned, the loudspeaker system succeeded in reducing much of what he had to say to inaudibility. But judging by his graceful tribute to the lady guests he was very much on form. And comments afterwards bore this out.

Indeed, in reply on behalf of the guests, the HON. MR. JUSTICE STEVENSON said that it was the most charmingly proposed toast that he had heard. After referring to the guests as an august body of clients he went on to categorize them as the sort of people described by *The Times* as Top People. Clients or no, elevated or otherwise, they certainly enjoyed his delightful remarks—and the sad little story he told about the missionary and the lion.—F.T.M.

PRIVATE FLYING

H.J.C.'s Club Commentary:

Kermesse at Kidlington

● WHAT IS believed to be a unique occasion in aviation in this country is a "sales week-end" being organized by W. S. Shackleton, Ltd., the London aircraft sales firm, this week-end, April 26-27.

It is to be held at Kidlington aerodrome, Oxford, with the co-operation of the owners, Goodhew Aviation, Ltd., and the Oxford Aeroplane Club. Besides being for the inspection and sale of many different aircraft primarily suitable for training and air touring, the event looks like turning into a general get-together for the private flying world.

All private owners and all the clubs have been invited to attend. There should be about 50 aircraft for sale if the weather is kind enough to allow them to be assembled: they are at present in many parts of the country. They will range from all the well-known light types—Austers, Tiger Moths, Proctors, Messengers, Geminis and so on—up to a Dove; a Sycamore helicopter is also expected, along with some Continental visitors.

● ON SATURDAY the "*kermesse d'aviation*," as we might call it, will be open from about 14.30 hrs. until dusk, and on the Sunday from 10.00 hrs. until dusk. Mr. Keith Shackleton, a director of the company, tells us that visitors may "fly in, drive in or walk in—at their own risk."

Kidlington aerodrome is a grass airfield, six nautical miles N.W. by N. of Oxford. No landing fees will be charged. Catering, including an espresso coffee bar, will be in the hands of the Oxford Aeroplane Club. Visiting pilots who intend to stay over Saturday night are requested to bring along their own picketing gear. If people do not fly away any aeroplanes which they may buy they can be hangared at Kidlington for about a week after the event.

● AT THE **Oxford Aeroplane Club** 112 hr. were flown in March, plus 12 hr. dual instruction in members' own aircraft. Mr. John Elliot gained his licence. He is the owner of a Piper Tri-Pacer. The aerodrome was very busy on March 22-23, when the Tiger Club visited Kidlington, with a complement of Tigers, Hornets, a Jackaroo and a Turbulent.

Vickers Patrol

● A VERY successful tea patrol was organized by Mr. Hugh Scrope, secretary of the **Vickers Flying School,** at White Waltham, on April 12. Invitations to attack had been sent to the other works flying clubs associated with Vickers, which are the **Vickers-Armstrongs (Aircraft), Ltd., Weybridge Flying Club,** at Fair Oaks; the **Hurn Flying Club** at Christchurch, and the **Supermarine Flying Club,** which is divided into a northern section at Thruxton and a southern section at Eastleigh, Southampton.

The defending force consisted of two Autocrats, G-AGTT and G-AJEE, and an Auster 3, G-AHLI, along with the Miles Aries, G-AOGA, of Mr. Eric Pasold, who sportingly offered to help defend after two Tiger Moths of the West London Aero Club had been rendered temporarily unserviceable by the strong wind.

● THE ATTACK began soon after zero hour of 15.15 hrs., and from G-AJEE we soon bagged an Autocrat and a Tiger from Christchurch, and then a Taylorcraft from Thruxton, while in the other patrol sectors more engagements were taking place.

Visibility was not too good, and on returning to the aerodrome we found that about a couple of dozen attackers had arrived, 12 of them having successfully escaped detection before landing. The arrivals included four hungry Jackaroo four-seaters from Thruxton and several Tigers, Chipmunks, Hornet Moths and Austers of various types.

● IN MARCH the cold weather was responsible for reduced flying hours at the **Fair Oaks Aero Club.** In fact, according to the club's newsletter, one pilot was heard to remark, "Flying a Tiger this weather makes walking a pleasure."

P.P.L.s were gained by Messrs. R. C. Johnson, M. Burt and N. A. Neve, and A.T.C. Cadet Headley; first solos have been flown by Messrs. Cameron-Webb and Edgar.

● A SIMILAR tale of restricted flying for a similar reason comes from the **Surrey Flying Club** at Croydon, where in January, February and March this year respective totals of 61 hr., 140 hr. and 177 hr. were recorded. In this club's view, "there is nothing really printable you can say about it."

In March Messrs. G. B. Fell and F. Sturm flew solo; Messrs. G. N. Maxwell and Mike O'Brien have passed their tests for the P.P.L.

The club now has a Percival Prentice in the fleet on a trial basis, hired from Aviation Traders. It is available at £7 an hour. So far as we know, this is the first club-operated Prentice.

May 10 has been selected as the date for the club's Redhill reunion party, beginning at 20.00 hrs.

Ulster News

● ALTHOUGH it was suggested last year that the **Bristol and Wessex Aeroplane Club** might have to close down, it has apparently got over the troubles which threatened to bring this about, and we understand that it has just completed the best period in its 31-year history.

The club now operates at Lulsgate, and in the past 12 months recorded 1,512 flying hours. There are at present 404 members, including 189 flying members.

● CLUB FLYING in Northern Ireland, the end of which seemed certain a month ago, has been granted a reprieve.

The **Ulster Flying Club** at Newtownards, operated by Short Brothers and Harland, provides the only facilities for club flying in Northern Ireland, and a recent decision to close the club was met by an objection from its members. An emergency meeting was called while the aircraft (four Tiger Moths and an Auster) were actually being ferried to Rochester. The meeting was attended by Mr. G. B. H. Currie, M.P. for North Down, and the Mayor of Newtownards, Mr. William Harvey. A strong protest was issued to the management of Shorts with a request that both parties meet to discuss the matter. As a result the club

Photograph copyright "The Aeroplane"

AFTER TEA.—Members of the works flying clubs operated by the Vickers group, seen here after the tea patrol at White Waltham on April 12.

is to continue for one year, with the promise of increased financial support from the company. A flying committee is to encourage more people to fly with the club and so bring in more revenue.

It was part of the agreement that the position be reviewed next year, so this coming year will be a crucial one for the sport in Ulster.

● THE CHIPMUNK, G-AORV, has now arrived at the **Exeter Aero Club** and is in service in its silver-and-red colour scheme. This aircraft is registered jointly in the names of the Exeter and Plymouth Aero Clubs. The first pilot to convert to the new type was the club chairman, Mr. R. King-Farlow.

At present nine cadets are training with the club. In March, Mr. R. Woodley and Cdt. Cleverdon flew solo.

Mrs. Yvonne Pope, formerly of Denham, has now joined the staff and will assist Mr. Joe Heelas on instructional duties.

The club is to attack the **Plymouth Aero Club** in a tea patrol on April 27, and that club will invade Exeter for breakfast patrols on May 25 and June 27.

● THE hon. secretary of **No. 61 Squadron Flying Group,** an R.A.F. group affiliated to the P.F.A., writes that it has recently been disbanded. All correspondence regarding this should be sent to him (Flg. Off. J. Minter), at R.A.F. Upwood, Hunts, by May 9.

GLIDING NOTES

AFTER a day's immersion in clouds, the Long Mynd emerged again on Easter Sunday and an attempt was made to resume the inter-club rally with a 62-mile race to Nympsfield, the north-east wind having resumed its sway. David Scallon got 30 miles to Dinsmore but nobody else scored, so it was "no contest."

A more modest race of 34 miles southwards to Madley aerodrome, near Hereford, was announced for Easter Monday, and five pilots got there, using some bits of ragged cumulus just below a strato-cumulus overcast which occasionally broke to let the sun through. Under this unpromising sky, John Hickling and David Benton took the Midland Club's Eagle to the goal in 55 min. at 37.1 m.p.h. average. With a 12-15 knot following wind and 50 knot airspeed, they covered 18 miles from the top of their third and last thermal with a height loss of only 1,900 ft.; this would give a gliding angle of about 1 in 40 through still air, but was the air really still vertically? They finished the last four miles at 100 knots with a further loss of 500 ft.

Other speeds in the race were: 30.9 m.p.h. by Brian Jefferson (Derbyshire and Lancashire, Skylark 2); 28.5 m.p.h. by David Martlew (Surrey, Olympia); 24.3 m.p.h. by Keith Johnston (Derbyshire and Lancashire, Skylark 2).

* * *

The first two contest days put Johnston's and Kaye's Skylark 2 from Derbyshire into the lead with 172.4 points, followed by Green with 152, Jefferson with 150, and Martlew with 127.

Early next morning the contest was put out of everyone's mind by people bursting into the dormitories at 06.00 hrs. with news that "it" was beginning to "wave" all over the sky. Sure enough, there was a big, smooth sausage of low cloud over Stiperstones to the N.W., where the wind was coming from, and other streamlined shapes here and there over Wales. Four pilots were rapidly sent aloft, but soon found their ceiling at only 1,350 ft. above take-off, as the horizontal wind was weak and its vertical components correspondingly feeble. At 08.30 hrs. convection was already active enough to start breaking up the waves and at 09.30 a shower dispersed their remnants.

* * *

A final task of free distance was then set. A cold front was expected, but nothing exciting arrived; various murky cloud forms passed over from the north, but most of them were dead and looked it. Three pilots got away—one for 16 miles, while the other two set out for the Nympsfield site. David Kerridge, who shares the Olympia from Surrey with Martlew, encountered a rainstorm when nearly there and was pushed down to the bottom, but Michael Kaye landed on the site, winning for himself and Johnston, with their Skylark 2, the Mynd Cup, and for his club the beer tray.

The results were worked out as average scores per contest day in which each entrant took part. Kaye and Johnston averaged 90.8 points; Martlew, Kerridge and Burton, 78.7; Scallon, Hampton and Holder, 59.4; Green, 51.0; Jefferson and Blake, 50.1; and Hickling with Benton (two-seater), 50.0.

Good Friday, April 4, was the only satisfactory cross-country day of the Easter holiday, and then not everywhere. Although several people flew to the neighbourhood of Lasham from the Long Mynd, and Philip Wills flew the 15-m. Skylark there from Dunstable, Lasham itself was too clamped to get away from except by aero-tow to the South Downs for slope-soaring. From the London Club at Dunstable, Geoffrey Stephenson went to Edgehill and back (84 miles), Frank Foster to Maidenhead and back (50 miles), and John Westhorpe, who will come into the news again, 40 miles to Great Dunmow in an Olympia to complete his Silver "C."

* * *

NOW for the week-end after Easter. It began on April 11, when Alfred Warminger flew his Skylark 3 from Swanton Morley in Norfolk to Dunstable, 84 miles in just 2 hr. He reached 8,500 ft. by using snow showers. At the same time John Everitt, the London Club's chief instructor, was flying the club's Skylark 3 from Dunstable towards south-west England, when a snow shower forced him down alongside Stonehenge.

Saturday, April 12, brought a crop of records from Lasham, in a north-easterly wind with a gradient strength of 25 m.p.h. according to the weather chart, though it was reported there to be 35 m.p.h. The air appears to have been almost stagnant in an anticyclone over southern Sweden before it started to cross the North Sea the day before. At Lasham, Brenda Horsfield reports, well-defined cloud streets were forming in it, with their bases rising to 5,000 ft. during the day, though for some reason those pilots who tried to use the more southerly streets did not get far.

The biggest feat was by Nicholas Goodhart, who made the first flight to exceed 500 km. in Great Britain. He was first towed a long way upwind to a point north of Cambridge, said to be Witchford, though it was more likely the complicated railway junction outside Ely a few miles away, which would photograph well. From there he went W. by S. to Edgehill, then S. by W. to Boscombe Down, and finally W.S.W. in an attempt to reach St. Just aerodrome at Land's End, which he missed by only 10 miles. His average speed was 50 m.p.h. Although the three legs add up to more than 500 km. (311 miles), only the straight-line distance, 295 miles, counted as a new distance record for the United Kingdom. He flew his own Skylark 3, which he has now decided to use in the World Championships.

* * *

Next we have a British National two-seater goal-flight record, combined with a U.K. two-seater speed record to a 300-km. goal—the first to be set up—made by Wally Kahn and John Williamson in the former's new T-42, named "Regal Eagle." They were aero-towed to Odiham and then flew 194 miles to Perranporth at 43 m.p.h. average. Williamson was also responsible for the former British two-seater goal record, 131 miles, in company with David Kerridge.

The third lot of records was by Mrs. Anne Burns, of R.A.E. Farnborough, who flew the Skylark 3, which she shares with her husband, from Lasham to Perranporth, setting up U.K. women's records for distance, goal flight, and speed to a 300-km. goal. She also became the first British woman to complete the Gold "C," as she already holds the women's gain-of-height record with 10,500 ft.—and to acquire a diamond for a 300-km. goal flight.

Frank Irving, in a Skylark 3 which he partly owns, overflew his declared goal at Perranporth by four miles, so qualified for Gold "C" distance but not for a diamond. Peter Hampton flew his Skylark 3 to Exeter.

* * *

From the London Club at Dunstable, the same day, nine flights were made totalling 1,325 miles. Longest was 262 miles by Philip Wills, flying the Skylark 2 in which he will compete in the 15-m. class in the World Championships.

There were three flights to Roborough aerodrome, just outside Plymouth, starting by aero-tow upwind a few miles to Streatley, so as to give a clear 300-km. run.

* * *

SUNDAY, April 13, also saw the U.K. distance record broken again. David Ince was towed from Lasham upwind to Lavenham in the Olympia 419 which Tony Deane-Drummond is to fly in the World Championships. From there he made a straight-line flight of 315 miles to set up a new U.K. distance record, which was only three miles short of the present British national record set up by Nicholas Goodhart in the United States. But it took him 9 hr., and he just missed his goal of St. Just, landing at Sennen, 2¼ miles south of it and a mile from Land's End. Lasham reported no clouds, though at Dunstable there were some scrappy ones which helped four pilots to get away, the farthest flight being to Swindon.—A. E. SLATER.

CORRESPONDENCE

High-speed Exchange

YOUR comment beneath the photograph you publish on page 311 of the March 7 issue is acknowledged and understood! Unfortunately, John Fricker's combination is not possible in this aeroplane—at least I don't intend to try it!

The gentleman who joined me in the Spanish-style quickstep is Col. James H. Buckey, the commander of the 78th Fighter Group. The Group was stationed at Duxford during the War and so this "exchange" business is not new by any means.

Hamilton A.F.B., Calif., U.S.A. J. M. NICHOLLS.

No. 8's Thirty-one Years

I WONDER why you WILL try to do No. 8 Squadron out of one year in Aden! I wrote to you when you did it before and here you are again in your R.A.F. Birthday Issue saying "No. 8 Squadron has now been associated with Aden for exactly thirty of the R.A.F.'s forty years."

I can only repeat that if so, I was drawing pay as Adjutant of No. 8 Squadron at Khormaksar in 1927 under false pretences.

WING COMMANDER M. H. JENKS, R.A.F. (Retd.).

Thames Ditton, Surrey.

[Pictures of past and recent aircraft of No. 8 Squadron will be found below.—ED.]

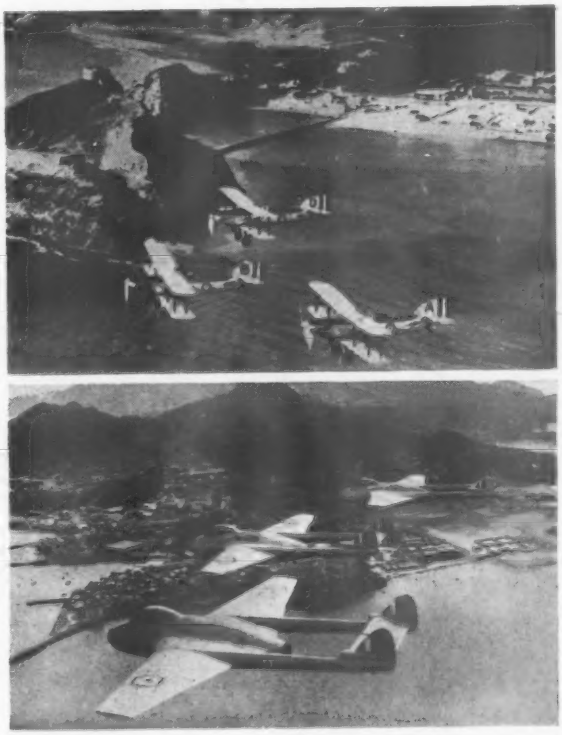
Pleasing Passengers

I CAME away from Mr. B. S. Shenstone's recent lecture, "Why Airlines are Hard to Please," feeling that our national airlines will continue to be hard to please whilst they remain preoccupied in competing for the favours of such a small proportion of the population, i.e., 0.1%.

One wonders whether life might not be easier if they could avoid "working on the edge of knowledge," to quote Mr. Shenstone. This is really the purpose of experimental units. It might well be more profitable if they set out to meet the less exacting demands of the other 99.9%.

More people would fly if:—

(1) Safety was unquestioned;
(2) Fares were halved;
(3) Regularity was assured.



EIGHT AT ADEN.—As our correspondent points out, No. 8 Sqn. has put in 31 years' service at Aden, illustrated by these contrasting views of its Fairey IIIFs in 1929 and de Havilland Vampire FB.9s in 1955. The Vampires have since been replaced by Venom FB.4s.

Unfortunately, none of these have really been achieved in Europe, and the recent choice of a jet airliner with its inevitable complexity seems once again to load the dice against these aims.

Mr. Shenstone's paper reflects the high technical standards prevailing in B.E.A., and technical people, of course, want faster and more advanced aircraft; but could not some of this technical talent concentrate on ways and means of achieving some of the less romantic, but very lucrative, aims even if speed is sacrificed?

Welwyn Garden City, Herts. K. V. BONNEY.

Wroundabout

"—and you can say that we are confident of beating these flying-machine chappies at their own game . . ."

*

Aviate to Rejuvenate. Listening to a broadcast in connection with the R.A.F.'s 40th Birthday, I was struck by the youthfulness of the voices of the men, now in their 60s and 70s, who flew with the R.F.C. and R.N.A.S. Col. Louis Strange, in particular, was as clearly young in spirit as on the day when he fell out of his inverted aircraft but clung to his gun mounting and eventually got back. As he said, "If you fell out, without a parachute, it could be a serious thing."

*

"What we need most is economy-size passengers."

*

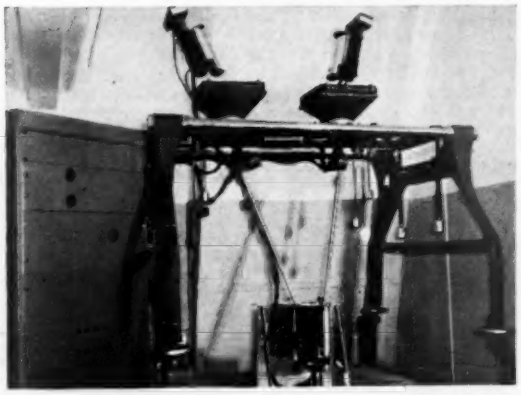
Paradise Found. Eddie Connellan, who runs Connellan Airways, serving Australia's Northern Territory, has come across the *Wroundabout* item which, with the help of an Alaskan airline's time-table, informed you of the whereabouts of Utopia—right there. Eddie sends his own time-table, noting that he serves a much warmer Utopia for you to retire to, north of Alice Springs, his headquarters. I see, too, that he has a tricky scale of cancellation fees: *Over 7 days' notice, NIL; over 3 days', 20% of fare; over 24 hours', 50%; less than 24 hours' notice, FULL fare.* I can just hear the customer on the 'phone: "Well, *my* watch says it's one minute *to* nine!"

*

Memories and Marks. Many of us find it difficult to accept the fact that we are making military aeroplanes for Germany, something we've never done before. It's partly to do with the '14-18 War's Iron Cross markings, I'm sure. On the German Sycamores, they instil a mild uneasiness in "Sox" Hosegood, Bristol's chief helicopter test pilot, as he delivers them, sometimes quite low to beat headwinds, across France and Belgium. "One of these days," he says, "some old farmer with a rifle in his hand won't be able to resist taking a shot at this reminder of the past."

by Wroundabout

NOTES AND EVENTS



AERIAL MAPPING.—A new automatic scanning correlator produced by the Photographic Survey Corpn., Ltd., of Toronto, for speeding up the process of interpretating aerial photographs. The machine measures the relative heights of image detail after automatically adjusting stereo pairs of photographs to their correct relative positions.

FUEL JETTISONING.—A new pressure-control valve (RV53/1) for use for emergency fuel jettisoning on the D.H. Comet 4 has been developed by the Hymatic Engineering Co., Ltd., of Redditch. Controlling the air tapped from the turbine compressor, the valve has a maximum inlet pressure of 135 p.s.i. and is intended to be used in conjunction with the Hymatic solenoid valve MD.32/1.

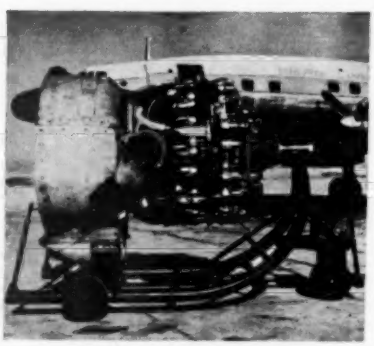
BRIGHTON ACQUISITION. — The Talbot Tool Co., Ltd., of Brighton, which manufactures "Grip" drill and reamer jig bushes, announces that it has acquired the share-capital and premises of K.D.L. Precision Engineers, Ltd., also of Brighton.

M.F. RADIO BEACON. — A new medium-frequency long-range beacon transmitter with a 10-kW. power output has been added to the range of Redifon beacons. Ordered by the M.o.S. for the R.A.F., the transmitter has been designed with particular attention to accessibility, and all components are readily reached from the front via roller shutters.

TEXTILES FAIR.—At the 1958 Industrial Textiles Fair held at the Royal Albert Hall, London, last week, the Fibres Division of Imperial Chemical Industries, Ltd., exhibited a number of applications of Terylene in aircraft equipment. These included webbing for ejector-seat harness in R.C.A.F. fighters to help resist damage; aircraft inflatable life rafts, and low-temperature hose for conveying cold air to aircrew ventilated suits.

BRITISH STANDARDS.—Two new aircraft standards have been published by the British Standards Institution and are now available from 2 Park Street, London, W.1, price 3s. each. They are "C.10:1958—Coupling dimensions for aircraft ground air conditioning connections" and "C.11:1958—Coupling dimensions for aircraft pressure-cabin ground test connections."

AIRCRAFT SPECIFICATIONS. — Two new aircraft material specifications —D.T.D. 869A "Laminated Safety Glass, High Light Transmission," and D.T.D. 870A "Bullet-Resistant Safety Glass, High Light Transmission"—have been issued by the M.o.S.



ENGINE OVERHAUL.—A Scoba Mk. 3 engine porter manufactured by Aerocontacts (Group Equipment), Ltd., of Gatwick Airport, in service with Iberia. The engine is an R3350 Wright Cyclone turbo-compound powerplant for a Lockheed Super Constellation.

Aviation Calendar

April 26-27.—Sales Week-end organized by W. S. Shackleton, Ltd., at **Kidlington Aerodrome**, Oxford. (See page 601.)

April 30.—R.Ae.S. Weybridge Branch A.G.M. at the Apprentice Training School, Vickers-Armstrongs (Aircraft), Ltd., **Weybridge**, at 18.00 hrs.

May 3.—British Interplanetary Society A.G.M. in the Kent Room, Caxton Hall, **London**, S.W.1, at 18.00 hrs.

May 4.—Tiger Club Aerobatic Competition, at **Sywell Aerodrome**, Northampton.

May 6.—R.Ae.S. Luton Branch lecture, "Analogue and Digital Computers," by Elliott Bros., in the Napier senior staff canteen, **Luton Airport**, at 18.15 hrs.

May 6.—Aviation Forum A.G.M. at the Imperial Hotel, Elizabeth Street, **London**, S.W.1, at 19.00 hrs.

May 9.—Helic. Assn. of G.B. lecture, "Canadian Research in the Field of Helicopter Icing," by J. R. Stallabrass, B.Sc.(Eng.), Grad.I.E.E., M.C.A.I. (National Research Council, Ottawa), in the R.Ae.S. Library, 4 Hamilton Place, **London**, W.1, at 18.00 hrs.

May 9-11. — International Air Rally organized by the Channel Islands Aero Club, at **Jersey Airport**, St. Peter.

May 15.—46th Wilbur Wright Memorial Lecture, "Automatic Flight—The British Story," by G. W. H. Gardner, C.B.E., F.R.Ae.S., at the Inst. of Mechanical Engineers, Birdcage Walk, **London**, S.W.1, at 18.00 hrs.

May 16. — Inst. of Navigation lecture, "The Principles of Inertia Navigation Systems," by E. W. Anderson, O.B.E., D.F.C., A.F.C., at the R.G.S., 1 Kensington Gore, **London**, S.W.7, at 17.15 hrs.

May 17-19. — Fourth International Air Touring *rassemblement* at **Quiberon-Le Roche**, France.

May 24-26.—R.Ae.C. of Belgium *bienvenue aérienne* at **Brussels.**

May 26.—Race Meeting organized by the Tiger Club at **Sandown Airport**, Isle of Wight, for the Basil Monk Trophy.

COMPUTER DATA.—Ferranti, Ltd., has published revised versions of two documents on its Pegasus computer. One, "The Description of the Ferranti Pegasus Computer," includes new information covering the company's operational experience with the unit and new magnetic-tape equipment.

Company Notices

NEW COMPANIES

Phoenix Aircraft, Ltd. (601,750).—Private co. Reg. March 31. Cap. £100 in 1s. shs. Objects: To carry on the business of designers and constructors of all types of aircraft engines, missiles and components, etc. Permanent directors: Cecil H. Latimer-Needham, High Oaks, Deer Park, Wonersh, near Guildford, director of Aeronautical Research and Design, Ltd., etc.; Arthur W. J. G. Ord-Hume, Mirador, Rose Mead, Lake, Sandown, I.o.W. Sec.: A. W. J. G. Ord-Hume. Reg. off.: The Old Mill, Cranleigh Common, Cranleigh, Surrey.

Rainbow Air Transport, Ltd. (601,835).—Private co. Reg. March 31. Cap. £5,000 in £1 shs. Directors: Thomas H. Hawkins and Mrs. Francine Hawkins, both of 6 Egerton Gardens, London, N.W.10. Sec.: T. H. Hawkins. Solrs.: Garber Vowles and Co., London, W.1. Reg. off.: 16 Soho Square, London, W.1.

C. C. Wakefield (Overseas), Ltd. (601,852).—Private co. Reg. April 1. Cap. £100 in £1 shs. Objects: To promote, develop and extend the trades and businesses carried on outside the United Kingdom and the Republic of Eire by C. C. Wakefield and Co., Ltd., and the subsidiary and associated companies and agencies of the said company, etc. Subscribers (each with one sh.): Leonard M. Broadway and William F. List, both of 46 Grosvenor Street, London, W.1, company directors. First directors not named. Solrs.: Bell, Brodrick and Gray, 29 Martin Lane, London, E.C.4.

New Patents

APPLICATIONS ACCEPTED

796,091.—Smitsvonk, N.V., and Nederlands Instituut Voor Vliegtuigentwikkeling.—"Helicopters with combustion chambers on the rotor blade tips."—Sept. 15, 1954 (Oct. 20, 1953).

796,177.—Folland Aircraft, Ltd., and Davies, I. J.—"Aircraft ejector seats."—Sept. 25, 1956 (Sept. 26, 1955).

Applications open to public inspection on June 4, 1958; opposition period expires on Sept. 4, 1958.

Personal Notices

BIRTHS

Bell.—On April 11, at Newtownards, Co. Down, to Doris, wife of Stanley Bell, M.S.A.E.—a son.

Doggett.—On April 9, at Lossiemouth, to Jennifer (*née* Cayley), wife of Flt. Lt. A. C. Doggett, R.A.F.—a daughter.

Fletcher.—On April 4, at Nicosia, to Jennifer (*née* Bellam), wife of Flg. Off. P. Fletcher—a daughter.

Hancock.—On January 19, to Elizabeth, wife of Flt. Lt. R. M. Hancock of R.N.Z.A.F. Station Wigram—a daughter.

Jenkins.—On April 7, to Barbara (*née* West), wife of Wg. Cdr. H. P. Jenkins—a son.

Millgate.—On April 12, at Cambridge, to Dorothy (*née* Polakoff), wife of Flt. Lt. L. Millgate—a son.

Reeve.—On April 7, at R.A.F. Hospital, St. Athan, to Jean (*née* Webber), wife of Flt. Lt. M. P. J. Reeve—a daughter.

Spiers.—On April 11, at Andover War Memorial Hospital, to Cynthia (*née* Williams), wife of Flt. Lt. R. J. Spiers—a daughter.

Taylor.—On April 9, at Howe Hill Nursing Home, York, to "Pip" (*née* Cox), wife of Flt. Lt. D. M. Taylor, R.A.F.—a son.

Waddington.—On April 7, at Newquay, Cornwall, to Beryl, wife of Flt. Lt. D. Waddington, D.F.C.—a son.

MARRIAGE

Cooper—Woodhouse.—On April 5, at All Saints' Church, Warlingham, Flt. Lt. D. A. Cooper, to A. B. Woodhouse.

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